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NATURE

A WEEKLY JOURNAL OF SCIENCE

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> Of nature trusts the Mind that builds for aye"—WORDSWORTH

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Volume 183

JANUARY 3, 1959, to ~~JUNE~~ March. 28, 1959

With Index. Jan – June

LONDON
MACMILLAN AND CO., LTD.
NEW YORK: ST. MARTIN'S PRESS, INC.

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REORGANIZATION OF INDUSTRIAL MICROBIOLOGICAL RESEARCH IN BRITAIN

THE Council for Scientific and Industrial Research has been considering certain aspects of the organization and support of microbiological research which is at present being carried out at the Water Pollution Research Laboratory, the National Chemical Laboratory, the Ditton Laboratory and the Torry Research Station at Aberdeen. The Council believes that an industrial microbiological team is able to do the best and most effective work when it operates within a research laboratory concerned with the technology served by the team. This is a point of view with which one must agree where industrial research is concerned, and in the present case it is well exemplified by the microbiological research now being undertaken in the Water Pollution Research Laboratory and the food research laboratories.

Although the Microbiology Group at the National Chemical Laboratory, numbering less than twenty, has undoubtedly done good work, the Council considers that the Group is not appropriately placed there; and therefore, apart from those working on the corrosion of metals, the chemical groups in that Laboratory do not benefit from the work of the microbiologists and, possibly, *vice versa*. So the Council believes that microbiological research work of the kind being done at the National Chemical Laboratory, apart from that concerned with the corrosion of metals, would in general be most effectively carried out in some university departments; and it is proposed to encourage support of such work within the universities by means of financial aid.

As a result of this, the Council is aiming at gradually dispersing the Microbiology Group now working at the National Chemical Laboratory. It is suggested that in future the work should be carried out as follows: (1) the Department of Scientific and Industrial Research will continue to maintain the National Collection of Industrial Bacteria, though it should go to the Torry Research Station, Aberdeen, where there is already a comparable collection of marine bacteria; (2) the microbiological work concerned with the corrosion of metals will be retained at the National Chemical Laboratory and expanded there; (3) the fundamental work on sulphur bacteria, at present being done at the National Chemical Laboratory, will end, though allied work, if justified, may be supported at a university; (4) fundamental work on the microbial formation of methane can be carried out at a university. The applied research covered by (3) and (4) is within the field of activity of the Water Pollution Research Laboratory, where any further necessary work in this connexion will be done.

The views of the Microbiology Committee of the Chemistry Research Board were made known fully to the Board itself, the Secretary of the Department of Scientific and Industrial Research and the Review Committee of the Council for Scientific and Industrial Research and, through the last-named, the Steering Committee of the National Chemical Laboratory and the Council. As a result, it is intended that the staff of the Microbiology Group at present working at the National Chemical Laboratory will be disbanded as such: the National Collection of Industrial Bacteria together with some workers will go to the Torry Research Station; some work will be transferred to the Water Pollution Laboratory; other workers will remain at the National Chemical Laboratory.

This proposal, which involves the division and dispersal of certain industrial microbiological research, and especially the removal of the National Collection, from the National Chemical Laboratory has not met with general approval, which is, perhaps, to be expected. Indeed, some microbiologists and others view the proposal with concern and are hostile to the idea of its being carried out before further inquiries have been made and the opinions of other scientists, especially microbiologists, sought. For example, the Institution of Professional Civil Servants and the Institute of Biology consider that the decisions being contemplated by the Council of Scientific and Industrial Research are to be deplored on both economic and scientific grounds. Moreover, they point out that there is no microbiologist on the Council, and they claim that, since the recommendation was made without the Microbiological Research Sub-Committee having been consulted, then this was done before proper advice was sought.

Mr. Stanley Mayne, general secretary of the Institution of Professional Civil Servants, believes that the existence of the present Microbiology Group in association with the National Collection of Industrial Bacteria is of considerable importance to many industrial concerns, as exemplified by the number of inquiries that are made. Nevertheless, in spite of Mr. Mayne's claim, it does not seem feasible that the work of dealing which such inquiries as are made or are likely to be made will become impossible if industrial microbiological research is distributed over a number of establishments. Much other closely connected scientific work is farmed out to different centres, both government and university, yet it does not appear to suffer in consequence. In fact, too much centralization and concentration can be a bad thing.

In a statement issued jointly by the Institution of Professional Civil Servants and the Institute of Biology on December 15, the main criticism was that advice had not been obtained from those most competent to judge before an important move was announced by the Research Council. Be that as it may, as already stated, certain authorities were advised beforehand, and, in any event, it does not follow that the decision is a bad one, especially if the main objective of those responsible for making it was the advancement of microbiological research for the benefit of the nation in general and industry in particular.

The joint statement claims that the disbanding of the Microbiological Group at the National Chemical Laboratory is ill-advised and, if implemented, will damage the national economy, for "its function cannot satisfactorily be discharged by any other body". This criticism seems premature, especially in view of the future arrangements for microbiological research being contemplated by the Council for Scientific and Industrial Research. The views expressed by the Council do not imply that microbiological research will be abandoned altogether; neither is it suggested that the work now being done will be handed over to an incompetent body. It appears that the move aims at so dispersing the Group that each new subdivision will find itself working in the most appropriate and advantageous environment.

It certainly seems a pity that the National Collection of Industrial Bacteria should be separated from the research unit as a whole; though some microbiologists will no doubt still be in direct association with it. In any event, if there is to be dispersal, then the Council has no choice other than to recommend the removal of the Collection to a place where it is of maximum service to science and industry; if, as is suggested, only the microbiological work on metal corrosion is to remain at the National Chemical Laboratory, then there seems little justification for the Collection remaining where it is. Most type collections and other national collections are inevitably centred at one, or just a few, places, in spite of the fact that cognate research may be very widely dispersed. It is difficult to see how this can be avoided. As the joint statement issued by the Institution of Professional Civil Servants and the Institute of Biology points out, removal of the Collection to Aberdeen might prove inconvenient, especially since, as the tatement claims, the majority of requests for technical help, the supply of cultures and the checking of purity come from the south of Britain. Moreover, visitors from abroad would probably find the siting of the Collection at Aberdeen somewhat of a nuisance. Apart from this, however, if the Collection is to be moved at all, Torry Research Station appears to be a very appropriate institution. The joint statement suggests that the Microbiology Group should either stay where it is or, if it is to be transferred out of the Department of Scientific and Industrial Research, it should be linked with the Microbiology Research Establishment of the Ministry of Supply at Porton. But the Council's statement says that if it goes to the Torry Research Station, the National Collection will still be maintained by the Department of Scientific and Industrial Research. Movement to Porton would bring the National Collection and its personnel in touch with medical instead of marine biological research, so, apart from difference in geographical site, the suggested move to Porton as opposed to Aberdeen seems to have little to recommend it.

The Institution of Professional Civil Servants and the Institute of Biology have made it quite clear that they deplore the splitting up of the present Group, and suggest that it should be established as a self-contained entity within the Department of Scientific and Industrial Research. Although there is much to be said in favour of this, the Council for Scientific and Industrial Research has also much in its favour in suggesting that microbiologists should work in a research laboratory most closely connected with the technology involved: this latter proposal must inevitably lead to a certain amount of farming out of the work. There is certainly much to be said for fundamental investigations of sulphur bacteria and the microbial formation of methane and, indeed, other aspects of microbiology, being supported by and in certain universities. Indeed, the Institution of Professional Civil Servants and the Institute of Biology concur with this proposal. The selected universities would offer certain biological and other facilities not to be found elsewhere. Such a development would seem to follow closely along the lines of policy adopted by the Australian Commonwealth Scientific and Industrial Research Organization, under the auspices and financial support of which varying scientific and industrial research laboratories are actually situated on the campuses of every university in Australia.

Other aspects of the case have, so far as we are aware, not been mentioned; for example, possible domestic problems and probably upheavals due to personnel being moved from the south of England to Aberdeen and the longer distances to be travelled in order to attend most conferences and meetings of learned societies, etc. But if the move is deemed of real advantage to the development of microbiological research, such obstacles must be accepted and overcome.

Obviously there is a schism in opinion concerning this case; and there is much to be said in favour of the proposal and against it. It can be taken for granted, however, that the Council for Scientific and Industrial Research delved deeply into the various aspects of the case before advising the splitting up of the Microbiology Group at the National Chemical Laboratory; so it will be a matter of time before judgment can be brought to bear on the proposal, if carried out. On the face of it, despite the disadvantages involved and inconveniences incurred, the distribution envisaged by the Council might well contribute to the advancement and advantage of industrial microbiology. The merits of division and dispersal may outweigh the demerits of disruption to the benefit of fundamental and applied microbiological research.

PROFESSIONAL METEOROLOGY AND EVERYDAY NEEDS

Everyday Meteorology

By Prof. A. Austin Miller and M. Parry. Pp. 270 + 22 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 30*s.* net.

Farming Weather

By L. P. Smith. (Nelson's Agriculture Series.) Pp. ix + 208 + 8 plates. (Edinburgh and London: Thomas Nelson and Sons, Ltd., 1958.) 15*s.* net.

BRITISH people are notorious for using their weather as a conversational gambit and as an alibi for Latin holidays. This combination of naïve intolerance and bemused escapism is reflected in the startling fact that the Meteorological Office is run, quoting Prof. A. A. Miller, "on a total annual budget of little more than the cost of a single modern bomber". Moreover, the proportion of this pittance allocated to specialized weather forecasting and advisory services, for example, for farmers and growers, is small compared, for example, with that devoted to upper-air research. The current preoccupation of our mathematical meteorologists with the physics of the atmosphere and the traditional restriction of Dunstable to sweepingly generalized forecasts marketed afterwards in newspapers and on television screens has perpetuated our habitual neglect of applied meteorology in terms of our everyday needs.

It is not surprising that, of the two volumes under review, one has been written by two geographers pledged to teach the weather not only *per se* but also in relation to society, and the other by a meteorologist pledged to direct weather advice to farmers and growers. Both books achieve an easy, readable style.

"Everyday Meteorology" deals with the origin and collection of weather data, the causes of weather, and the significance of frontal zones and air masses in the atmospheric circulation. Local and world types of weather are then described and finally some problems of weather forecasting, of 'living with' the weather and of 'harnessing' the weather, are discussed. Attempts at three-dimensional representation of weather systems are, unfortunately, few and in two instances quite misleading. In Figs. 38 and 39 upper winds relating to horizontal profiles are inserted on vertical cross-sections through frontal systems. The impression given in the second diagram is of a wind blowing down towards the Earth's surface through a large cumulus cloud. Parts of Chapter 9 are conspicuously inadequate in reference to soil climate, the growing season and land aspect. "A soil containing much water" is not necessarily "a clay soil" (p. 192), and the optimum insolation slope varies with the time of year between south-west and south-east (p. 197). These and other minor omissions and inconsistencies tend to detract from what is otherwise an attractively compiled work which renders accessible to the layman many meteorological ideas which might otherwise be beyond him.

"Farming Weather" aims at a particular section of the popular market. It presents a digestible and comprehensive survey of weather elements and factors and weather forecasting as they affect agriculture. The lack of precise recommendations to farmers on coping with weather hazards may be criticized by some. It should be stressed, however, that every farm, indeed every field, may require different weather advice because of small-scale variations in land morphology, soil conditions and associated micro-climates. Generalized advice, even for a local district, may be relatively useless. Adequate consultation of L. P. Smith's book should enable the farmer, or grower, to plan his programmes so as to anticipate certain weather hazards and accommodate them when they occur.

Professional meteorology would benefit by devoting more effort than heretofore to the applied problems so ably discussed in these two volumes. "Meteorology without Mathematics" may be regarded as impracticable and futile by the meteorologists, but mathematics without a morphological approach to weather study seems unlikely to provide us with a properly trained and localized advisory weather service.

JAMES A. TAYLOR

THE LIVING MOLLUSC

Molluscs

By Dr. J. E. Morton. Pp. 232. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 10*s.* 6*d.* net.

ALTHOUGH Dr. J. E. Morton states that there has been no general book on malacology written in Britain for forty-five years and so claims comparison with B. B. Woodward's brief "Life of the Mollusca", his book bears comparison better with Pelseneer's "Mollusca" published in 1906. Of necessity both much shorter and far less fully illustrated, yet it marks a notable stage in the growth of knowledge concerning the most structurally diverse of the invertebrate phyla. Pelseneer's volume represented the culmination of a notable period of comparative anatomy; it left the stage set for elucidation of the function of organs there so clearly described.

Dr. Morton's book represents the first comprehensive attempt, probably in any language, to summarize what has more recently been discovered about the function and significance of these organs, adding up in many cases to a very full understanding of the mode of life of the animals possessing them. He is particularly well qualified to deal with such matters by the beauty of his research and the distinction of his writing. Thus we read that "If pulmonates lack the structural variety shown by opisthobranchs, this is because they have made a much more subtle use of physiological adaptations", that the Gastropoda are a "living museum of adaptive morphology, nearly every family having some distinctive pattern to show", that nudibranchs are "the most colourful and extravagant of all gastropods", that "cephalopods are organized upon a more stereotyped pattern than gastropods or lamellibranchs; but this is a pattern of high success". He surmises that the extinct ammonoids "could make leisured saunters".

There is much to praise in this book and for any student of the Mollusca, as I have found, to learn from it. The restriction on length has made possible a price well within the range of all, amateur, student or professional zoologist, interested in malacology. It is, however, unfortunate that there is so little space and so indifferent a printing surface for the text-figures at which the author excels.

All this is not to say there is not matter for criticism. The impression is given that the bivalves possess a 'two-piece' shell, whereas the ligament is an integral part of the shell. Those who study oysters will be surprised to discover that at no stage is there a foot or a byssus gland, also that the adult may "break free". Although classification of the bivalves is far from satisfactory, matters are not improved by employing that of Douvillé.

C. M. YONGE

RESPONSES OF INVERTEBRATES

An Introduction to the Behaviour of Invertebrates

By Dr. J. D. Carthy. Pp. xi+380+4 plates. (London: George Allen and Unwin, Ltd., 1958.) 45*s*. net.

HERE is a useful summary of a large volume of literature on some responses of invertebrates to experimental stimulation. It is not, therefore, a textbook of behaviour, which is a larger subject including spontaneous activities, memory and central control mechanisms. There are chapters on the responses to stimulation in each of the main sensory modalities, including humidity changes and the contact chemical sense, in addition to those more familiar from our own experience. The final chapter, on whole patterns of behaviour, is disappointing, since the behaviourist approach and that of the neurologist are both excluded, leaving an account of the reactions to combined stimuli.

The coverage is excellent. The recent literature is summarized together with the old, but in some instances the necessary re-interpretations are not forthcoming. First, for example, in this decade a number of workers have shown that the angle of light acceptance of an ommatidium is wide compared with the interommatidial angle. Much of the earlier work on visual acuity and form vision by the apposition compound eye must now be attributed to post-retinal mechanisms. For a longer period it has been known that the principal physiological responses of many eyes change with time, and, in particular, some rapidly moving diurnal insects have little but an 'on' and an 'off' response. Form vision must then depend on relative movement of the eye and the object, and again must be attributed to post-retinal integration. Hassenstein's analysis of the *Wechselfolge* of *Chlorophanus* is an example of the new approach to this mechanism. Secondly, a most important theory of the relation between spontaneous movements and the responses to stimuli is that of von Holst; this is barely mentioned under the name re-afferentation, but not explained. Recent results from the Tübingen school demonstrate the explanatory value of these concepts in this field, and they deserve a better treatment.

In my own special field the literature summary is accurate, a judgment which can probably be extended to the remainder. The difficulty is not the labour of being acquainted with the material; it is the comprehension of its relation to the main body of knowledge. The solution of this problem distinguishes a synthesis from a compilation.

However, this is mild criticism. The book represents the painstaking and useful labour of summarizing a vast, diffuse and unsatisfactory field of zoology. The responses of whole animals to the somewhat artificial circumstances required by experimental analysis are notoriously difficult to interpret. Often a particular species is studied by only one author, so that comparisons are difficult and may not be valid. The experiments must often be made statistically with a large number of animals so that the mechanism within an individual is not easily approachable. This brings me to the final point. The introduction of delicate electrophysiological methods for the analysis of the actual performance of sense organs as transducers has led to a quiet revolution in our appreciation of the various parameters of a stimulus which can possibly be of importance to the animal. The problem of the origin of the integrated response is thereby usually pushed back into the central nervous system, but at least an advance is made. Neither this book, nor its predecessors, claims to synthesize this more recent neurophysiological analytical approach with the 'behaviour' of the whole animals. Perhaps the effort is doomed to frustration for a long time to come.

G. A. Horridge

FACT AND VALUE IN THE SOCIAL SCIENCES

Value in Social Theory

A Selection of Essays on Methodology. By Gunnar Myrdal. (International Library of Sociology and Social Reconstruction.) Pp. xlvi+269. (London: Routledge and Kegan Paul, Ltd., 1958.) 32*s*. net.

IN this book, Dr. Myrdal faces a simple but at the same time unsolved problem which has overshadowed the social sciences since their inception, namely, the relation between statements of fact and statements of value. As an economist, he found himself in his earlier days compelled to reject the solution of the "welfare economists"; in later years he was equally repelled by the "naïve empiricism" of the American institutional school, with the result that the value problem has come to be a "major preoccupation" for him, and questions of methodology have been for many years one of his continuing interests.

Dr. Myrdal's position at the present time is directly dependent on an acceptance and development of the view that 'objective' values cannot be established and known by scientific processes; subjective evaluations can be observed and analysed, but their validity and their significance for social theory only arise out of their acceptance by specific individuals and groups. In consequence, when Dr. Myrdal produced his great survey of race relations in the United States, "The American Dilemma", he made his value premises explicit, and based them so far as possible on observation. He made no attempt to argue that they could be incorporated in a body of fact and doctrine created by the research itself. He now concludes in the present book that valuations are necessary in all scientific work, and that "the final solution of the value problem in economic and in the social sciences generally must . . . be to set up a method by which human valuations are rationally and openly introduced into theoretical and practical research to give it direction and purpose to make it both unbiased and relevant to life". No research can, therefore, be *wertfrei*.

This is the point at which Dr. Myrdal leaves the argument in his "Postscript". It may be pointed out, however, that it is somewhat paradoxical to speak of the 'introduction' of values into research in this way because the very nature of science as a human activity is dependent on the logical presupposition that it should be unbiased. Moreover, as Mr. Streeten points out in the introduction to Dr. Myrdal's essays, the analysis and public discussion of beliefs and valuations tend to produce changes in them, and scientific inquiry thus plays its part in their formation. There is thus a connexion between fact and value, to this extent at least. If, however, it must be concluded that the social sciences cannot be 'objective' in Max Weber's sense because the connexion is not a logical one, there is nevertheless a limited area within which their explanation of man's behaviour is scientific, because, as Dr. Myrdal puts it, "there *is* a great deal of practically mechanistic causation in human life"; in particular, resistances to social change are "enormous", and the tendency for social phenomena to repeat themselves is correspondingly great. The true paradox in the social sciences which lies at the end of the Myrdal–Streeten argument is then that as the deeper understanding of social phenomena makes it possible to free them from the operation of 'mechanistic causation' in some measure, the social sciences must be supposed to contain within them, to the same extent, the seeds of their own destruction.

T. S. Simey

BIOCHEMISTRY IN MEDICINE

Advances in Clinical Chemistry

Vol. 1. Edited by Harry Sobotka and C. P. Stewart. Pp. xi + 398. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 12 dollars.

While most aspects of biochemistry have been adequately covered in many recent review journals, clinical chemistry has featured in the literature of recent years more in the form of new outlets for original papers and in a spate of fairly elementary texts. The present volume is therefore to be welcomed, since it is the first of a series in which selected topics will be reviewed thoroughly and authoritatively by experts who are actively working in the field which they describe. The authorship of this first volume is thoroughly international in composition; of the nine authors five are in Europe, three in America and one in Australia, while the two editors live in New York and Edinburgh respectively.

Any publication dealing with clinical chemistry is liable to become a mere compendium of methods. While methods feature very prominently, and rightly so, in this book, their appearance is balanced by an equally exhaustive discussion of what the editors term "the fundamental biochemical abnormalities which underlie disease". The choice of subjects has been very skilfully made to give a wide coverage of problems of topical interest. Thus the chapter by Wróblewski on the clinical significance of transaminase activities in serum is a welcome reminder that this enzyme is of interest in several conditions other than coronary thrombosis. The topical subject of 5-hydroxytryptamine and related compounds is covered by Dalgleish in a survey which differs from other recent reviews in being predominantly biochemical rather than pharmacological. Thyroid function is dealt with in Chaney's chapter on the analytically complex problem of the determination of protein-bound iodine and in Silver's contribution on plasma-levels of iodine-131. Plasma iron is competently dealt with by Ramsay. Two chapters which are essentially methodological, but which will be welcomed for their detailed and critical treatment of their subjects, are Neher's review of the determination of individual adrenocortical steroids and Owen's section on paper electrophoresis of proteins. Josephson contributes a brief but useful chapter on the composition of body fluids in childhood, and in collaboration with Ek also discusses the assessment of the tubular function of the kidneys.

Without attempting to detract from the value of the book, I would like to express an objection to the term 'clinical chemistry'. The subject so named, unless it be regarded merely as a technical exercise in chemical analysis, is essentially a division of the wider discipline of biochemistry in which biochemical principles are applied to the scientific study of disease in the hospital laboratory. While 'clinical chemistry' is certainly preferable to the alternative term 'chemical pathology', the most appropriate title is undoubtedly 'clinical biochemistry' or 'pathological biochemistry'.

J. N. Davidson

THE COLOURS OF DOGS

The Inheritance of Coat Color in Dogs

By Clarence C. Little. Pp. xiii + 194. (Ithaca, N.Y.: Comstock Publishing Associates, Cornell University Press; London: Constable and Co., Ltd., 1957.) 34*s*. net.

Most scientific breeders and geneticists will already know Dr. C. C. Little's book, which is making its appearance here under an English imprint. It gives the results of many years of research at Bar Harbor and in the author's own dog colony into the inheritance of the coat-colour patterns of most of the commercially important breeds of dog. In all, ten loci, some with several alleles, are discussed, and 4,100 pups of twenty-eight breeds have been raised in the laboratory colony—the rest of the results have come from co-operating breeders, through the American Kennel Club. This successful co-operation, which seems to have been very critically carried out, is one of the most interesting features of the study. Genetics are not the only field in which use could be made of the large number of dogs bred annually—longevity studies and surveys of the incidence of tumours have recently been attempted for various breeds, and although colour-scoring places a less exacting demand on those breeders who co-operate, the scale of Dr. Little's support is encouraging as an index of what could be done with this otherwise wasted biological information.

Breeders themselves stand to gain from the results of the study; the author has attempted to accommodate them, in a book directed chiefly to professional geneticists, and secondarily, perhaps, to veterinarians, by including a short refresher chapter on the mechanisms and terminology of inheritance, but this will only make his findings clearly intelligible to non-biological readers if they have a reasonable prior knowledge of genetics.

The results are concisely presented, first by loci and then by breeds. It is difficult for anyone not in the field to criticize the detailed conclusions reached. For the generality, one of the most useful items is a summary list of twenty-one breed- and colour-types where the genes represented are known with reasonable certainty. Little considers that 'true' albinism, with complete absence of skin pigment and with pink eyes, probably does occur in dogs, and that the 'blue-eyed' albino dogs and cats mentioned by Burns arise by a different mechanism. The effects of various modifiers upon the extent of pigment patches are well illustrated by drawings. Cases of supposed red-black somatic mutation in cocker spaniels are discussed: here as elsewhere the book is a provocation to the pigment chemist to find out the nature of the differences induced genetically between adjacent skin areas. It sticks strictly to its last, however: there is no general discussion of pigment epigenetics, and only incidental treatment of the problem of analogy between canine and other mammalian pigmentation genes; the substance of Dr. Little's recent and authoritative review of coat-colour genes in rodents and carnivores would be a useful additional chapter for future editions without making the book overlarge, and would widen its use for reference purposes. It is already a valuable standard work, and a tribute to the patience of its author which only those of his colleagues who work with the longer-lived mammals will fully appreciate. ALEX COMFORT

FLORA OF WEST AFRICA

Flora of West Tropical Africa
The British West African Territories, Libreria, The French and Portuguese Territories South of Latitude 18° N. to Lake Chad, and Fernando Po. By Dr. J. Hutchinson and Dr. J. M. Dalziel. Second edition revised by R. W. J. Keay. Vol. 1, Part 2. Pp. ii+297–828. (London: Crown Agents for Oversea Governments and Administrations, 1958.) 55*s.*

SCIENCE, fortunately, need not always wait on politics, and for thirty years the essential unity of the Upper Guinea region of Africa has been recognized and provided for by an excellent "Flora". It is not without interest to trace the historical background.

During the middle part of last century large collections of dried plants (herbarium specimens) began to arrive at Kew from what was then the British Empire, and Sir William Hooker, followed by his son Sir Joseph Hooker, initiated and undertook the vast project of providing "Floras" of these territories. The four major works, which started publication in 1860, were, in chronological order: "Flora Capensis", "Flora Australiensis", "Flora of Tropical Africa" and "Flora of British India". Of these the "Flora of Tropical Africa" (Vol. 1, published in 1868) was by far the least satisfactory for, with a few exceptions, only the periphery of the area was well known, and the earlier volumes often contained no more than about 10 per cent of the species now known to science. In the later decades of the nineteenth and the earlier decades of the twentieth centuries German botanists, inspired by Adolf Engler and encouraged by the political climate of German imperial expansion in Africa, did a vast amount of botanical work on tropical Africa, often without very close co-operation with similar work at Kew and the British Museum. By the 1920's the taxonomy of the flora of tropical Africa was in real confusion, and it was realized at Kew that a solution had to be found. Whether it would have been better to start a new edition of the "Flora of Tropical Africa" (the first edition of which has not been entirely completed to this day) is a matter of opinion, but the decision was taken, probably rightly, to start a new series of African regional "Floras". With institutional and, indeed, international co-operation, botanical work on Africa south of the Sahara has proceeded along that course with a fairly satisfactory regional division of the territory, leaving, however, a few unfortunate lacunae, of which the French Cameroons – French Congo region is the worst.

This brief historical summary is necessary to see the "Flora of West Tropical Africa" in perspective. It was the first of this new series of regional floras but differed fundamentally, in many respects, both from its aged parent and from its later successors ("Flore du Congo Belge", now well advanced; "Flora of East Tropical Africa", in course of publication; and "Flora Zambesiaca", in gestation). The original edition was initiated by Sir Arthur Hill, then director of Kew, financed by the British West African Governments, entrusted to Mr. (now Dr.) J. Hutchinson and the late Dr. J. M. Dalziel and completed over the period 1927–36. This represented very rapid work, and speed of production and conciseness were two of its main features. Synonymy, references and descriptions were cut to a minimum; but there were rather elaborate keys containing descriptive elements and the illustrations were generous. The arrangement of the families departed considerably from Bentham and Hooker traditions by following Hutchinson's own ideas on classification—usually, though not invariably, an improvement on the older one.

The work was at the time the only large-scale modern "Flora" of tropical Africa available and was in great demand not only in the territories for which it was intended but also throughout Africa, providing, often enough, the means for the field-botanist to achieve at least generic determinations anywhere in Africa south of the Sahara. It is not surprising that the first edition soon sold out, and it is gratifying that Kew has been able to undertake a much-needed revision and second edition.

This second edition was entrusted to Mr. R. W. J. Keay, of the Department of Forest Research, Nigeria, assisted by Mr. F. N. Hepper and several other members of the Kew staff. Keay, with an excellent knowledge of the plants obtained in the field, most unusually joined with an admirably balanced taxonomic judgment, has made a magnificent job of it, correcting the many errors which had not unnaturally been discovered with the passage of time in the original work and reorganizing some portions completely, although keeping the original format and reconciling so far as possible the conflicting claims of accuracy and speed. It is a splendid work of the highest value and importance taxonomically, ecologically and economically. To see the extent of change and progress represented by the second edition, one may turn to the important genus *Cola*, entirely rewritten with the help of Mr. J. P. M. Brenan, and note that twenty-five species have expanded to forty-two and that nine more are recorded as still imperfectly known.

The part now under review is of great economic importance, containing the Leguminosae (divided into Caesalpiniaceae, Mimosaceae and Papilionaceae) and the Meliaceae (African mahoganies). In reviewing a second edition it is hard to decide exactly what criticism is legitimate, in view of the fact that the format of the original cannot be drastically changed. Though Keay has partially removed them, there still remain traces of a certain Kew insularity. It is, one supposes, to be taken as almost axiomatic that any specimen cited is represented in the Kew Herbarium; but this is not always so, and it may be suggested that the internationally accepted system of herbarium abbreviations should have been used to indicate the location of specimens. Of minor errors there are, of course, a few, inevitably so in a work on this scale, but the general standard is very high and to pick out the odd slip for criticism would reflect more on the mentality of the reviewer than on the ability of the editor. The price (55*s.* for 532 pages) is a considerable increase on that of Part 1 (25*s.* for 295 pages) and a stronger paper cover might have been provided in view of the increased bulk. A. W. EXELL

NEW INVESTIGATIONS WITH SCEPTRE-III

From the Research Laboratory, Associated Electrical Industries Ltd.,
Aldermaston Court, Aldermaston

Axial Positive Ion Velocities in Sceptre III

By T. P. HUGHES and DR. S. KAUFMAN

THE spectral lines of highly ionized atoms in the high-current discharges in Zeta and Sceptre[1] show marked Doppler broadening. It has yet to be shown conclusively that the ion motion involved is due to a high ion temperature. If this is the case, one of the conditions which should be satisfied is that the broadening should be independent of the direction from which the discharge is viewed. In the work referred to above, the discharge was viewed only in the radial direction, that is, perpendicularly to the gas current. One aim of the experiments reported here was to make observations of the broadening in the directions parallel to, as well as perpendicular to, the gas current.

The other aim was to measure ion drift velocities. It has been shown[2,3] that those deuterons which undergo nuclear reactions have a mean centre-of-mass velocity parallel to the gas current of about 5×10^7 cm. sec.$^{-1}$. One interpretation of these observations is that a small fraction of the deuterons are accelerated to velocities of about 10^8 cm. sec.$^{-1}$, and that these react with other comparatively slow deuterons[2]. Another possible interpretation is that the gas is moving parallel to the current with a velocity of 5×10^7 cm. sec.$^{-1}$. If impurity ions such as O V were to possess a comparable drift velocity, a marked wave-length displacement would be detected by tangential spectroscopic observations. This point has also been made very recently by George[4]. In this work, preliminary observations have shown that the magnitude of the O V Doppler widths is independent of the line of sight and that some impurity ions (for example, O V, C V) possess axial velocities of about $(1 - 2) \times 10^6$ cm. sec.$^{-1}$ in the direction of positive ion current.

The optical arrangement is shown in Fig. 1. Light leaving the centre of the discharge tangentially was directed into a Hilger medium quartz spectrograph either by the mirrors, *A*, *B* and *C* or by *A′*, *B′* and *C′*, thus allowing observations in opposite tangential directions to be made. The mirror *C* could be replaced by the mirror *C′*, or removed completely to permit radial observations. Spectra from these three lines of sight were recorded for comparison using a Hartmann diaphragm placed in front of the spectrograph slit. Only short exposures of about 50–100 discharges were possible because the quartz window in the torus wall soon became covered with an opaque metallic deposit. The customary few hundred discharges needed to reach stable operating conditions after opening the vacuum system to the atmosphere were therefore omit-

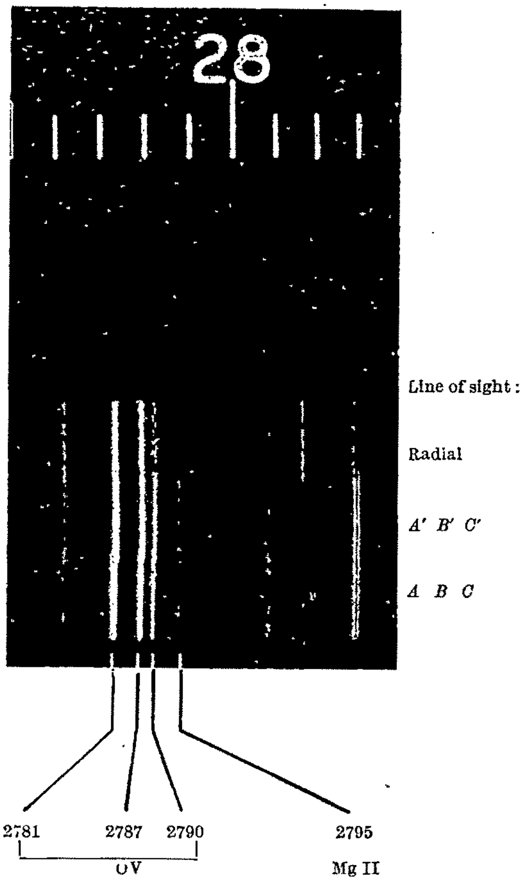

Fig. 2

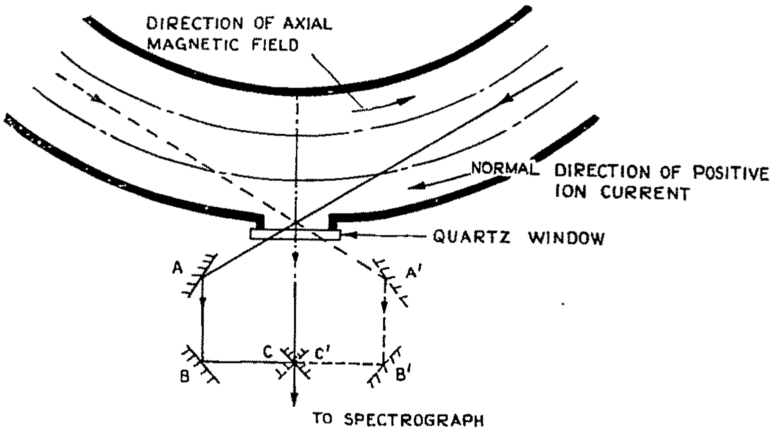
DIRECTION OF AXIAL MAGNETIC FIELD
NORMAL
DIRECTION OF POSITIVE ION CURRENT
QUARTZ WINDOW
A
A′
C
C′
B
B′
TO SPECTROGRAPH

Fig. 1

Table 1. COMPARISON OF OBSERVATIONS IN RADIAL AND TANGENTIAL DIRECTIONS

No. of primary turns	Direction of electric field	Initial axial magnetic field (oersted)	Ion	Displacement		Mean ion velocity (cm. sec.$^{-1}$)	O V half-intensity width			Mean O V ion 'temperature' (deg. K)
				$\Delta\lambda$ (A.)	$\Delta\lambda'$ (A.)		ΔW_R (A.)	ΔW (A.)	$\Delta W'$ (A.)	
16	normal	1,000	O V	−0·07±0·05	+0·08±0·05	(0·8±0·4)×10^6	0·8±0·1	0·7±0·1	0·8±0·1	(1·4±0·3)×10^6
16	normal	500	O V	−0·14±0·05	+0·16±0·05	(1·6±0·4)	0·7±0·1	0·7±0·1	0·7±0·1	(1·1±0·2)
			C V	−0·18±0·06	+0·21±0·06	(2·6±0·6)				
16	reversed	500	O V	+0·13±0·05	−0·10±0·05	(1·2±0·4)	0·5±0·1	0·6±0·1	0·6±0·1	(0·6±0·1)
8	normal	500	O V	−0·13±0·05	+0·12±0·05	(1·3±0·4)	0·7±0·1	0·7±0·1	0·8±0·1	(1·2±0·2)

Gas, deuterium at a pressure of 1·4 millitorr; condenser voltage, 25 kV.

ted, with the result that the impurity concentration was abnormally high.

The spectrograms showed that measurable displacements occurred in the wave-lengths of the O V triplet at λ2781 A., and, in the one set of exposures where it could be seen, of the C V triplet at λ2271 A. These lines are most strongly excited in the central region of the discharge column[5]. The displacements of the O V lines when the direction of the electric field is normal may be seen in Fig. 2, which is an enlargement of a typical spectrogram. Many other lines showed smaller displacements. However, the wave-lengths of several lines of singly ionized metal atoms did not vary perceptibly from one direction of view to another: these lines are but feebly excited at the axis of the torus. One of them, the Mg II line λ2795·53 A., was therefore used as a reference wave-length from which the position of each member of the O V triplet, when viewed in the three different directions, could be obtained by microphotometry: another, the Cu II line λ2276·25 A., served as a reference wave-length for the C V triplet. The results are shown in Table 1. The wave-length displacements are given with respect to the wave-lengths obtained from the radial observations, the latter being in good agreement with published values. Δλ is the mean displacement of the triplet when the discharge is viewed using the mirror system *ABC*, and Δλ′ is the corresponding value when viewing with *A′B′C′*. The mean velocities of the emitting ions have been obtained from these displacements on the supposition that they are due to the Doppler effect alone. The Zeeman effect, which would produce symmetrical splitting of the lines, must be discounted. Only the quadratic Stark effect need be considered. This cannot account for more than a small fraction of the observed displacements because it would produce a shift in one direction only, irrespective of the line of sight. The ion velocities are in each case in the direction of positive ion current flow.

On the basis that the intensity ratio of the two strongest lines of the O V triplet is independent of the direction of view and has a value of 2·0 (measured in previous radial observations when an intensity calibration of the photographic plate was possible) the half-intensity width of the strongest O V line was measured. In Table 1, ΔW_R is the width observed in the radial direction of viewing; ΔW and $\Delta W'$ were obtained for the two tangential directions using mirror systems *ABC* and *A′B′C′* respectively. The mean O V ion 'temperature' was obtained from the average of these widths over all three directions, by the method of Voigt profiles.

The agreement between the Doppler widths for different viewing directions is consistent with the broadening being caused by real O V ion temperatures of about 10^6 deg. K. occurring in the plasma under the operating conditions described above. The existence of such temperatures is not proved conclusively because light from many discharges is required for a single measurement and the possibility of random mass motion still remains. The directed velocities of the O V ions are more than an order of magnitude less than the centre-of-mass velocity of the reacting deuterons. Nevertheless, they are unusually large for positive ions, and their implications are considered by Ware in the following communication. In future work it is hoped to measure these velocities more exactly with a spectrograph of larger dispersion and to ascertain their dependence on ion mass and charge.

We are indebted to Dr. A. A. Ware for helpful suggestions during the preparation of the manuscript and for his constant interest in the work. It is a pleasure to acknowledge the co-operation of Mr. R. F. Hemmings and Mr. J. E. Read, who were responsible for the engineering and operation of Sceptre.

This work was supported in part by a contract from the Atomic Energy Research Establishment, Harwell, and is published with the permission of Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Limited.

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The Positive Ion Heating Mechanism in Sceptre III

By DR. A. A. WARE

IN the many experiments which have been made on the pinch effect in both straight and toroidal discharge tubes, the results indicate consistently an electron temperature (T_e) well below that predicted theoretically assuming no heat losses. The electron temperature has been deduced from the electrical conductivity[1,2], spectroscopic data[3,4] and microwave measurements[4], and the results all lie in the range 5 × 10^4 to 5 × 10^5 deg. K. With no heat losses the energy dissipated in the gas would have yielded temperatures 10–100 times greater (see, for example, Allen *et al.*[5]). Similar low electron temperatures are observed in the Stellarator[6]. Several speculations have been made concerning the mechanism by which the electrons lose their energy[6–8], and an important piece of evidence was obtained by Colgate[2], which indicated that a large flux of electrons with energies in the range 2–4 keV. was striking the walls. This

Table 1

Measured quantities					Derived quantities		
Applied magnetic field (gauss)	Gas current I (amp.)	Electric field in gas, E (volt cm.$^{-1}$)	Discharge radius, a (cm.)	O V-ion velocity v_0 (cm. sec.$^{-1}$)	Deuteron density n_d (cm.$^{-3}$)	Deuteron velocity v_d (cm. sec.$^{-1}$)	Electron velocity v_e (cm. sec.$^{-1}$)
500	$1\cdot0 \times 10^5$	$3\cdot0$	8	$1\cdot6 \times 10^6$	$3\cdot5 \times 10^{14}$	$4\cdot6 \times 10^6$	$-4\cdot4 \times 10^6$
1,000	$1\cdot4 \times 10^5$	$2\cdot3$	$10\cdot5$	$0\cdot8 \times 10^6$	$2\cdot0 \times 10^{14}$	$6\cdot0 \times 10^6$	-7×10^6

$N_d = 7 \times 10^{16}$ cm.$^{-1}$

flux was estimated to be of the right order of magnitude to explain the energy loss.

The results of measurements of Doppler broadening of spectral lines from Zeta[9], Sceptre III[5] and the Stellarator[10] are consistent with the positive ions having temperatures appreciably greater than the electron temperature and in the range 10^6 to 5×10^6 deg. K. Because of the possibility of a mass motion occurring in the gas with random magnitude and direction, the results do not prove the existence of these temperatures. If the temperatures are real, the result $T_{\text{ion}} > T_e$ is novel for discharges of this type. Thus, one of the main processes by which the ions were expected to be heated was by collision with electrons[10], but if the ion temperature is greater than the electron temperature, this process becomes a cooling mechanism. Furthermore, the compression of the gas due to the pinch effect is not sufficient to cause the observed ion temperatures, and hence another heating mechanism must be sought.

In the preceding article, Hughes and Kaufman report that the O V and C V ions in Sceptre III have unusually large mean velocities parallel to the gas current. This result suggests a simple picture of the discharge, which is consistent with the high electron energy loss and explains the positive ion heating mechanism.

The Deuteron Velocity

A simple discharge model is taken in which the particle densities and temperatures, and the current density, are assumed uniform over the cross-section of a stationary and stable discharge. (The constant current density is indicated by magnetic probe measurements[11]. The assumption of constant particle density and temperature is not likely to introduce major errors in the following order of magnitude calculations. The assumption of complete stability is least justified because high-frequency oscillations are observed on the magnetic probe signals, and something must be causing the high electron energy losses.) The discharge is assumed to be in equilibrium in the radial direction, and the only motions considered, other than thermal motion, are in the direction of the main gas current. If v_e, v_d and v_0 are the mean velocities of the electrons, deuterons and O V ions respectively in this direction, and if a steady state is assumed, the following mobility equations hold for the O V ions and deuterons respectively:

$$4Ee + f_{e0}\, m(v_e - v_0) + f_{d0}\, M_d(v_d - v_0) + \sum_i f_{i0}\, M_i(v_i - v_0) = 0 \quad (1)$$

$$Ee + f_{ed}\, m(v_e - v_d) + \sum_i f_{id}\, M_i(v_i - v_d) = 0 \quad (2)$$

E is the component of the electric field in the direction of the gas current, m and M_d are the masses of the electron and deuteron, and f_{xy} is the collision frequency for momentum transfer for ions of type x colliding with a single ion of type y. The symbol i refers to an impurity ion, and the summation must be made over all types of impurity ion present, but with the omission of O V ions in equation (1). The loss of momentum by the particles to the walls has been neglected (see below). The gas current is given by:

$$I = N_d e\,(v_d - v_e) + \sum_i N_i Z_i\, e\,(v_i - v_e) \quad (3)$$

where N_i is the number of ions of type i per unit length of the discharge and $Z_i e$ the charge on such an ion.

That the terms due to impurities are of significance in equations (1)–(3) is suggested by the intensity of impurity spectral lines and also by the fact that without impurity terms, equations (2) and (3) yield a value for T_e (from f_{ed}) of 9×10^4 deg. K., whereas the measured temperature was $2\cdot5 \times 10^5$ deg. K.[3]. (T_e was obtained from the relation $f_{ed} = n_d e^2 \eta_\perp / m$, where the resistivity $\eta_\perp$ is given by Spitzer[12a].) The presence of the impurity terms makes it impossible to solve the equations because the densities and velocities of the various impurities are unknown. It is possible, however, to form general conclusions concerning the velocity v_d.

In order to do this, the impurity terms containing i are at first neglected in the three equations. Using the experimental results for two of the cases reported by Hughes and Kaufman (preceding communication), the values of f_{ed} have been calculated from equations (2) and (3) and then v_d and v_e from (1) and (3). The value of f_{e0} was obtained from the relation:

$$\frac{f_{e0}}{f_{ed}} = \frac{Z_0^2}{Z_d^2} = 16 \quad (4)$$

The quantity f_{d0} was calculated using the expression given by Spitzer[12b], with T_d assumed equal to T_0 (see below) and taking $n_d = N_d/\pi a^2$, where a is the observed radius of the discharge from magnetic probe measurements (Table 1) and N_d the number of deuterium atoms present initially in the discharge per unit length.

The results in Table 1 give values of v_d greater than v_0 and approximately equal to $-v_e$. That v_d should, in general, be greater than v_0 can be seen from the fact that f_{e0} is 16 times greater than f_{ed}, whereas the electric force on the O V particles is only four times greater. Hence the electric field should cause the deuterons to have a larger drift velocity with respect to the electrons than the drift velocity of the O V particles, so that $v_d > v_0$. The deuteron – O V collision term acts merely to reduce the magnitude of the difference between v_d and v_0.

Considering now the effect of the impurity terms, in general the ratio f_{i0}/f_{id} will not be 16, because the average relative velocities between colliding particles will not be the same for the two types of collisions as was the case in equation (4). However, provided that:

$$\frac{T_d}{T_0} > \left(\frac{16\ M_d}{Z_0^4 M_0}\right)^{1/3} \simeq 0\cdot 2$$

f_{i0}/f_{id} will always exceed 4, and the electric field will cause the deuterons to have a larger drift velocity with respect to the i-particles than that of the O V ions and again $v_d > v_0$. The inclusion of the impurity terms in equations (1) to (3) plus the fact that a higher electron temperature must be taken to satisfy equation (2) leads to values for v_d closer to v_0 than those in Table 1. Thus for the given experimental conditions the theoretical model predicts that v_d lies in the range $v_0 < v_d < (v_d - v_e)/2$.

Using the velocities from Table 1, the net momentum of the gas per unit length of the discharge is approximately NM_dv_d, neglecting the contribution due to impurity ions. This is of the order of 1 dyne sec. cm.$^{-1}$. The momentum received by the electrons per unit length of the discharge during the time to reach peak current ($t \simeq 300$ μsec.) is of the order $-2N_dEet/\pi$, which is about -50 dyne sec. cm.$^{-1}$. Hence the large ion velocities are explained if the electrons lose to the walls about 2 per cent of the momentum that they gain from the electric field. The simplest explanation of this momentum loss is that there is an appreciable electron particle loss to the walls. As already mentioned above, Colgate has obtained evidence for such a loss in his experiment. In the case of Sceptre III, if it is assumed that the momentum loss is carried by electrons in this way, the losses of momentum and energy can be reconciled, provided the mean energy of the electrons reaching the wall is less than 2 keV.

The Positive Ion Heating Mechanism

A significant feature of the above estimates of v_d is that the positive ions are carrying an abnormally high fraction of the gas current; the fraction is somewhere in the range 6–50 per cent. (If there were no losses from the discharge, the electrons and deuterons would have equal and opposite momenta, and the deuterons would carry only 0·03 per cent of the current.) Thus, the positive ions will receive a substantial fraction of the energy input directly from the electric field. The energy is converted to thermal energy as a result of particle collisions, and if collisions with electrons are the main resistance to the positive drift velocity then most of the energy will be transferred to thermal energy of the electrons because of the low electron mass. If, however, the dominant collisions are those with impurity ions, that is, if the sum of the terms containing f_{id} in equation (2) exceeds the term containing f_{ed}, the deuterons will retain most of the energy, since the impurity ions have masses large compared with the deuteron mass.

Assuming the latter to be the case and neglecting cooling processes for the deuterons other than by collisions with electrons, the deuterium temperature is given by:

$$Eev_d = \frac{3}{2}k\left(\frac{T_d - T_e}{t_{ed}}\right) \qquad (5)$$

where t_{ed} is the relaxation time for energy exchange and is given by Spitzer[12c]. Using the two limits obtained above for v_d, the deuterium temperature should lie in the range 8×10^5 to $1\cdot 7 \times 10^6$ deg. K. for the 500 gauss case and 6×10^5 to $2\cdot 8 \times 10^6$ deg. K. for 1,000 gauss. In the case of the O V ions, in order that these ions should retain most of the energy they receive from the electric field, the impurity ions must be the main resistance to the O V motion and most of the ions must have masses greater than that of oxygen. (Copper and aluminium have strong lines in the spectra.) In such a case the equation for the O V particles corresponding to equation (5) predicts values of T_0 of $1\cdot 3 \times 10^6$ and $1\cdot 0 \times 10^6$ deg. K. for 500 and 1,000 gauss respectively. In any event, at the temperatures involved here the rate of exchange of energy between deuterons and O V ions is about twice as rapid per unit temperature difference as that between O V and electrons. Hence, in general T_0 would be nearer to T_d than to T_e. Thus the theory predicts positive ion temperatures close to those indicated by the Doppler broadening (T. P. Hughes and S. Kaufman, preceding communication).

Conclusions

A simple model has been taken for the discharge in Sceptre III, and on this basis it has been deduced that the deuterons should have a mean velocity somewhat greater than that observed for the O V ions. The appreciable gas momentum involved is consistent with the electrons losing to the walls a small percentage of the momentum they receive from the electric field.

The discrepancy between the electron temperature calculated from the resistivity of the gas and that measured spectroscopically suggests that impurity ions may play a major part in scattering the deuterons. If this is so, the deuterons will retain most of the energy they receive from the electric field, and positive ion temperatures of the order of magnitude indicated by Doppler broadening for O V are to be expected. The theory thus shows that there is a simple and consistent explanation of the Doppler broadening on the basis that thermal motion is the cause. Because of the simplifying assumptions which have been made, however, the theory cannot be regarded as a proof of the existence of such temperatures.

I wish to acknowledge many helpful discussions with Mr. B. S. Liley and other colleagues at the Associated Electrical Industries Research Laboratory and with members of the Thermonuclear Division at the Atomic Energy Research Establishment, Harwell. The work reported here has been done under contract to the Atomic Energy Research Establishment, and I am grateful to Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Ltd., for his continued encouragement and permission to publish this communication.

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ELECTRONIC COMPUTERS IN THE SERVICE OF BUSINESS

At a distance of some days, it is possible to unscramble the many and varied impressions created at the Electronic Computer Exhibition and Business Computer Symposium (Olympia, London, November 28–December 4), and to consider what one feels are the more important implications. One may put aside such technical developments as the increasing use of printed circuits in place of wiring and of transistors in place of thermionic valves: such matters are applicable to the electronics industry as a whole. One may also disregard a number of technically interesting but somewhat irrelevant demonstrations, and the bread-and-butter exhibits of stationery, furniture and office equipment. It then becomes apparent that the most prominent feature of the Exhibition and Symposium was the emergence, in parallel, of a classic approach to the introduction of integrated electronic data-processing for business purposes, and of a fashion in the design of computer systems directed to cater for this approach.

That business has now taken over from scientific research the role of principal instigator of the development of computers can be clearly inferred not only from the types of computer system on show, but also and more directly from the fact that the majority of displays were of computer systems rather than of simple computers. The predominant trend in design is towards what Lord Halsbury in his opening address to the Symposium described as the "fully literate computer": one which is designed to read information from the widest possible range of input media (manual keyboard, punched paper tape, punched cards and magnetic tape), and can write information on an equivalent range of output equipment; one which, moreover, can grant a considerable measure of autonomous control to its input and output facilities so that these may proceed independently, transferring information to or from buffer storage in readiness for the central computer's demands. Such a trend must be to the gratification of one manufacturing organization, at least, which was operating electronic data-processing equipment on something approaching this basis at a time, four years ago, when no other general business electronic data-processing installation existed.

In an attempt tp keep up with this trend, some small and medium-sized computers have followed the tactics of the puffer fish. Though thoroughly competent in the role for which they were originally designed, these machines are being required to support a burden of peripheral equipment out of all proportion to their normal capacity. Prospective purchasers may well consider whether there can be any justification for tying upwards of £100,000 worth of input, output and ancillary storage equipment to the apron strings of a computer which is incapable of utilizing effectively more than a small proportion of its potential activity. It was equally regrettable to note the manner in which one or two exhibitors sought to attract attention by stunts which had little or no connexion with the intended application of their equipment. "Good wine needs no bush", and an effective computer does not require a 'gimmick'.

In respect of ancillary equipment, one could discern another important trend. While mechanical equipment is being pushed to the utmost to achieve greater speeds of printing, punching and hole sensing, in one corner of the exhibition could be seen the all-electronic writing on the wall. A prototype printing device was on show in which the characters, delineated by deflexions of the beam of a cathode-ray tube in response to signals decoded from a magnetic tape, are used, by means of a system of optical projection and static charges, to deposit powder in appropriate shapes upon a continuously moving roll of paper. The powder is then bonded to the paper by heat treatment, emerging as a succession of lines of print to be taken upon an output roller. The speed of output by this equipment is of the order of ten times that of the most rapid mechanical line printer on show, yet the only moving parts are the slowly revolving rollers. Elsewhere could be seen prototype equipment which, by use of cathode-ray tube scanning and photo-multipliers, could, in a continuous process, read typescript characters from a document and code these in computer language on to magnetic tape. Such equipment, when perfected, will have two great advantages. High-speed mechanical equipment, particularly when reciprocating motion is involved, is not infrequently subject to mechanical breakdown. In order to avoid interrupting the flow of work while spare parts are obtained and repairs are made, it has become common practice to install an expensive spare machine which will be idle for a considerable part of the time. Moreover, the direct automatic conversion from original document to computer language and from the latter to printed output will eliminate the intermediate steps in which human errors are likely to be introduced.

The classic approach to an integrated electronic data-processing system was apparent in a well-developed form in three of the papers presented at the Symposium, and in an embryonic state in at least three more. It reflects the growing confidence of business management in the feasibility of such a system, as exemplified by the comment of one speaker that if his system of completely integrated data-processing did not prove satisfactory he would be obliged to seek a new occupation. This attitude is a far cry from the somewhat timid and tentative approaches to electronic data processing of some applications represented at the Symposium but not representative of it. The classic approach involves a penetrating research into the very fundamentals of the existing business system, questioning why the various functions are performed, rather than investigating the exact manner of their performance. It is essential, of course, that such an investigation should be carried out under the close direction of persons of managerial or senior supervisory calibre. Many speakers at the Symposium were agreed that it was equally necessary that the 'organization and methods' personnel concerned in investigations for an electronic data-processing system should have a sound general knowledge of programming techniques and that programmers should be acquainted with 'organization and methods' procedure. The two can then work in close collaboration to determine the nature of the original information available for input and that of the various types of output information which should be proved necessary or desirable. From this they would devise an efficient system for achieving the requirements, using the full range of equipment available. Carried to its logical conclusion, such an investigation should not consider the somewhat arbitrary divisions into which a business may be divided at present (for example, wages and salaries, cost accountancy, production and stock control, sales invoicing), but should include the whole scope of the business. This may sound a Utopian concept, but it is already being attempted by some, and is considered the essential goal by many others.

The essential element of such an approach is the open mind, uninhibited by existing manual or punched-card clerical systems. Some business organizations which have not yet installed mechanized systems of any kind have considered adopting a little-by-little approach; a gradual transition by introducing first a punched-card system, then a small-scale computer, and finally a fully developed large-scale computer system. To these the experience of one business organization may be of interest and provide some guidance. The spokesman of this concern explained that the computer system now being installed bears very little resemblance to the punched-card system which preceded it, although he acknowledged that the latter had provided some useful experience in planning.

It is true that the applications of a limited scope may sometimes be of outstanding importance. A saving of the order of £50,000 per annum for the expenditure of three or four hundred pounds was reported at the Symposium from the application of linear programming techniques to a problem of bulk transportation, and an account was given of how an hour or so a week on a small computer had made possible the introduction of a greatly improved method of production control. But in general, the most substantial benefits will come from a comprehensive system. This does not imply that an integrated system can be installed in one operation. The system must be planned with the view of dividing it into phases which are of such a size and nature that they may be introduced in sequence over a period of many months. The transition, indeed, requires some of the most careful and detailed planning, for each phase must be introduced with the least possible disturbance both to work already on the computer and to procedures which are still carried out manually. It is normally advisable to run each new phase on the computer in parallel with the previous system until it is reasonably certain that all eventualities have been covered. Furthermore, it is prudent to prepare in advance an emergency procedure for adoption in the event of a serious breakdown of the equipment, however unlikely this may be.

Compared with strategical planning of such complexity, the tactical programming may well prove relatively simple. However, just as interpretive routines and automatic coding techniques permit the computer to assist the programmer, so may some of the computer techniques which are being developed in the field of operational research be of assistance to the planner. A paper on developments in this field was presented at the Symposium, and the speaker agreed with a suggestion that the simulation techniques which he had described could be used to study the feasibility of systems designed for a business electronic data-processing installation. A large organization might find it worth while to acquire a small computer initially for this purpose. If this machine were compatible with the peripheral equipment of the proposed large installation, it could later be used in conjunction with it, and would prove invaluable for carrying out those housekeeping activities such as sorting and merging which occupy so much of the time of a large computer while exploiting so little of its capabilities. This, then, may represent the pattern for the future use of electronic computers in business.

In conclusion, I wish to make it plain that the opinions expressed above are of a purely personal nature, and should not be construed as representing the policy of the organization with which I am associated.

W. L. C. Garrett

SCIENTIFIC CENTENARIES OF 1959

By JOAN M. EYLES

ONE of the first requisites for the traveller is a good map of the country in which he proposes to travel. If none exists, then his travels will help to provide one. The launching of the First Crusade in 1095 by Pope Urban II marked the beginning of a series of mass pilgrimages across Europe which continued for nearly two centuries and must have given rise to a demand for maps, guides and charts to help the traveller on his way. The earliest medieval maps of Britain are those made by Matthew Paris, the great historian. Matthew, a Benedictine monk of the Abbey of St. Albans, died seven hundred years ago, in 1259, and his maps of Britain are believed to date from 1250. Their main object was probably to show the towns and monastic guest-houses where the pilgrim could rest on his way to Dover, the usual point of departure for the Holy Land. Many of the legends on the maps are of interest; Snowdon is both named and shown by an outline of a mountain, a convention that survived on maps until the middle of the eighteenth century, when hachuring came into use. Other maps prepared by Matthew Paris which still exist include one showing the route from London to southern Italy.

When William Harvey described the circulation of the blood in his "De Motu Cordis" (1628), he referred to the Italian anatomist, Matteo Realdo Colombo, who died in 1559, and whose work, "De Re Anatomica", appeared shortly after his death. Colombo, a pupil of Vesalius, made a close study of the blood vessels of the lungs and discovered experimentally the pulmonary circulation, although he did not understand or recognize the general circulation. Colombo was appointed successor to Vesalius at Padua in 1545, but went to Pisa in the following year and taught there. Later he moved to Rome, where he was teaching when he died.

Two authors of arithmetic books died in 1559. One was Cuthbert Tunstall, Bishop of London and friend of Sir Thomas More, whose "De Arte Supputandi", written in Latin and first printed in 1522, was the earliest arithmetic by an English author. The other was Adam Riese, born in Bavaria in 1489, who wrote a popular arithmetic and a treatise on practical geometry. His arithmetic was so widely used that "Nach Adam Riese" can be looked on as equivalent to the English expression "according to Cocker".

Among the bicentenaries of the year, that of the French scientist, P. L. M. de Maupertuis, who died on July 27, 1759, is particularly interesting. De Maupertuis was leader of the French expedition to Lapland in 1736 to measure the length of a degree of longitude, achieving results which verified Newton's theory that the Earth was an oblate spheroid. He became president of the Royal Academy of Sciences in Berlin, and was afterwards involved in a bitter controversy with Voltaire. It is worth recording that he also had ideas about evolution and made an early attempt to explain the origin of new species.

Jacob T. Klein, born in Königsberg in 1685, and author of several zoological works, also died in 1759. Klein visited England in the course of his travels, and in 1728 was elected a Fellow of the Royal Society.

A significant event of 1759 was the establishment of a botanic garden in the grounds of Kew House, on the instructions of Augusta, Dowager Princess of Wales and mother of George III. Some thirty years later, Erasmus Darwin wrote:

> "So sits enthron'd in vegetable pride
> Imperial Kew by Thames's glittering side;
> Obedient sails from realms unfurrow'd bring
> For her the unnam'd progeny of spring;"

From these beginnings arose the magnificent Royal Botanic Gardens at Kew which we know to-day.

Several well-known naturalists were born in 1759. In particular, we note Sir James Edward Smith (1759–1828), founder and president for forty years of the Linnean Society of London. The story of how the young botanist was breakfasting with Sir Joseph Banks and seized the opportunity of purchasing the collections of Linnæus has often been related. This memorable purchase was followed by several years travel in Europe, and on his return Smith founded the Linnean Society. This was not the first Society started by Smith, for some years before, when a student at Edinburgh, he and a few friends with similar interests had formed a Society for the pursuit of natural history, which was attended by men as prominent as Black the chemist and Hope the botanist.

Born on August 12, 1759, a few months before Smith, Thomas Andrew Knight, a country gentleman, also became known as a botanist and founder of a Society. Knight was another member of the Banks circle, and one of Sir Joseph's many correspondents. He became a Fellow of the Royal Society in 1805 and in the following year received the Copley Medal for his investigation of tropisms in plants. He also carried out extensive researches into the improvement of fruit trees by crossing. One of the founders of the Horticultural Society, he became its second president in 1810, a position he occupied until his death in 1838.

Another enthusiastic naturalist was the Rev. William Kirby, rector of Barham in Suffolk, whose name appears on the first list of Fellows of the Linnean Society. Kirby's chief interest was in entomology, and he is remembered as joint author with Spence of a popular introduction to entomology.

Three French naturalists born in 1759 were L. A. G. Bosc, who travelled extensively in North America, J. B. Audebert, artist and author of several beautifully illustrated books, including "L'Histoire Naturelle des Singes", and P. J. Redouté, the famous flower painter.

An interesting chemical anniversary is that of the birth of Thomas Cooper, free-thinker and student of the natural sciences, who emigrated to America in 1793. He was a close friend of Priestley, who bequeathed to him his chemical apparatus, including the historic burning glass used in the discovery of oxygen. Cooper taught chemistry and mineralogy in the United States for many years, first in Pennsylvania, then in Virginia, and later in South Carolina. His advanced thinking and love of free speech, which had led to his leaving England, brought him into further trouble in America, and in 1833, after writing to Silliman that "the Old as well as the New Testaments were by no means infallible guides in mineralogy and geology", he was forced to resign his position as president of the College of South Carolina. Cooper did much to spread the knowledge of the new chemistry of Lavoisier in the United States, and edited a number of chemistry text-books; but he was an unorthodox character, whom an English geologist described as "a most remarkable man some of whose screws were uncommonly loose".

The first practical demonstration of aerostation in England was made by Vincenzo Lunardi (1759–1806), a daring young Italian diplomat, who ascended in a balloon from Moorfields, London, on September 15, 1784. He travelled some twenty-four miles in two and a quarter hours, touching down at North Mimms on the way to land his cat, which was suffering from the cold. This aerial voyage was watched by thousands of people, including the Prince of Wales and prominent politicians.

Passing to 1859, undoubtedly the most eminent of the scientists who died in that year was Alexander, Baron von Humboldt. Born in Berlin in 1769, he studied first at Göttingen and later at the School of Mines at Freiberg. On leaving the latter he received an appointment in Berlin as superintendent of mines. For four years he carried out his duties, visiting mines and studying geology. In 1796 he gave up his post and devoted himself to further scientific studies in order to prepare himself for travel. After several disappointments, in 1799 he set sail for South America with the botanist Aimé Bonpland, having obtained special permission from the King of Spain to travel in and examine Spanish territories in the New World. It was five years before he returned to Europe, having travelled some 40,000 miles, bringing back with him more than thirty cases of geological and botanical specimens. During 1808–27 he made his home in Paris, which he regarded as the centre of the scientific world, and devoted himself to preparing detailed accounts of his travels and the collections he had made. In 1827 he moved to Berlin, and he remained in Germany until his death in 1859. He had hoped to travel in Asia as extensively as he had in America, but the realization of his hopes was limited to a nine-months journey across Russia and Siberia in 1829.

Humboldt made many contributions to science, in the fields of geology, geography and climatology, but he is also remembered for the inspiration he was to others, and in particular to Charles Darwin. The latter wrote in 1845: "I never forget that my whole course of life is due to having read and re-read as a youth his 'Personal Narrative'". A. R. Wallace, too, wrote of the influence this book had upon him. When Humboldt died, on May 6, 1859, he was within six months of his ninetieth birthday, and ten years later the centenary of his birth was celebrated with enthusiasm on both sides of the Atlantic.

Karl Ritter, the geographer, who also derived inspiration from Humboldt's writings, died only a few months later, in September 1859. Ritter did much to establish the science of comparative geography, and endeavoured to show that the physiography of a country had a direct influence on the life and progress of the nation inhabiting it.

Another scientific traveller who spent many years in the United States was Thomas Nuttall (1786–1859), a Yorkshire printer who emigrated in 1807. He was persuaded to take up botanical studies, and underwent many hardships during his solitary travels in the interior of the United States in search of specimens. He is said to have discovered an almost unequalled number of new genera and species. During 1825–34 he was curator of the botanic gardens at Harvard, but in 1841 returned to England to occupy a family estate at Nutgrove, near Liverpool, where he cultivated many rare plants. He died on September 10, 1859, and his herbarium of more than 5,000 species was purchased by the British Museum.

The British Museum also acquired the herbarium of Javanese plants belonging to Thomas Horsfield (1773–1859), a Pennsylvanian-born physician who practised in Java and Sumatra from 1799 until 1819, when he became keeper of the East India Company's Museum in London. Yet another botanist who died in 1859 was K. A. Agardh, born in Sweden, who published the first general account of diatoms. His "Systema Algarum" (1824) entitles him to be regarded as a pioneer in the classification of the algae.

In the field of geology, Denison Olmsted (1791–1859), a Yale graduate who became professor of chemistry, mineralogy and geology at the University of North Carolina, was one of the first to appreciate the value of a State geological survey. He laid a plan for one before the State legislature in 1821, and an Act authorizing such a survey was passed two years later. Olmsted received no fees, but expenses of 250 dollars a year. His preliminary reports were published in 1824 and 1825. He was then recalled to Yale as professor of mathematics and natural philosophy. Later he became professor of astronomy at Yale, and observed the return of Halley's comet in 1835, making the announcement long before confirmation arrived from Europe.

Four years after this event, Harvard decided to establish an observatory, and William Cranch Bond (1789–1859) was appointed 'observer', later becoming its first director. Bond was an instrument-maker in Boston with a taste for astronomy, who had constructed his own instruments and built an observatory at his home. When he died in 1859, he was succeeded at Harvard by his son, George Phillips Bond.

Three mathematicians of some note also died in 1859. The most senior, Louis Poinsot, was born in Paris in 1777. He was particularly interested in statics, but published a number of works on geometrical and mechanical subjects. The theory of couples is largely due to him, also that of the motion of a body in space under the action of no forces. J. L. Raabe, of Zurich, born in 1801, chose higher algebra for his field of research, and discussed the convergency of series; while Peter Lejeune Dirichlet, born at Duren in 1805, became a pupil of Gauss, and succeeded him at Göttingen in 1855. He is best known as an interpreter of Gauss and of Jacobi, his father-in-law, but is also remembered for having introduced into the calculus of variations the so-called Dirichlet principle.

The tubular girder railway bridge spanning the Menai Strait in North Wales and the High Level bridge across the Tyne at Newcastle both stand as memorials to the famous engineer, Robert Stephenson, son of an equally famous father. Stephenson died in October 1859, and was buried in Westminster Abbey.

Passing on to more recent times, and the centenaries of scientists who were born in 1859, we note first two who were awarded Nobel Prizes, Pierre Curie and Svante Arrhenius. Pierre Curie, born in Paris on May 15, 1859, married the young Polish chemist, Marja Sklodowska, in 1895. Six months later Röntgen discovered X-rays, and so began that well-known chapter of scientific history in which is recorded the Curies' joint investigation of the radioactive elements. Pierre had already studied the behaviour of crystals in electromagnetic fields, and had discovered the piezo-electric effect. To the joint research he brought a familiarity with delicate electrical instruments which proved of great value in determining the physical properties of the newly discovered elements. In 1903, the announcement by Pierre Curie and his pupil, Laborde, that radium emits heat rendered valueless Kelvin's estimate of the age of the Earth, based on its rate of cooling, and paved the way for an entirely new method of estimation, based on radioactivity.

In the same year, the Curies and H. Becquerel shared the Nobel Prize for Physics. Three years later, a street accident brought a tragic end to Pierre's life, though, as all know, the work on radioactivity was carried on valiantly by his widow, who herself received the Nobel Prize for Chemistry in 1911.

While Pierre Curie was studying the passage of electricity through crystals, Svante August Arrhenius, born near Uppsala on February 19, 1859, was investigating its passage through dilute solutions. His theory of electrolytic dissociation, first embodied in the dissertation for his doctorate in 1883 and published in full in 1887, received more support abroad, particularly from Ostwald and Van 't Hoff, than in Sweden. Recognition eventually came, and with it the Nobel Prize for Chemistry in 1903, and the establishment in 1909 of a Nobel Institute in Stockholm, which he directed until his death in 1927. His bold and original ideas were not confined to physical chemistry, but extended to the fields of serum therapy and cosmology, volcanism and the cause of glacial periods. Appreciation of his work was shown in British scientific circles by the conferment of foreign membership of the Royal Society and of honorary degrees by the Universities of Oxford, Cambridge, Edinburgh and Birmingham.

Two men born in 1859 both occupied prominent positions at the Rockefeller Institute for Medical Research in New York. One was Jacques Loeb, biologist and biochemist, born at Mayen in Germany, who left his homeland for the United States in 1891. He spent ten years in Chicago, seventeen at Berkeley, and was then made head of the Division of General

Physiology in the Rockefeller Institute, a position which he held until his death in 1924. Founder of the modern school of physiology, his early experiments in artificial parthenogenesis startled the scientific world by producing the fatherless sea-urchin and the fatherless frog. He investigated the effects of various stimuli upon living matter, and followed this by extensive research on proteins. Although a brilliant experimentalist, his philosophical ideas, particularly as stated in his "Mechanistic Conception of Life", aroused considerable criticism and opposition.

Loeb's contemporary, Theobald Smith (1859–1934), of Albany, New York, occupies an honoured place in medical science for his pioneer work investigating the transmission of disease and immunization. Inspired by the work of Koch, in 1889 he discovered the parasite responsible for Texas fever in cattle, and in his classic report of 1893 gave the first account of the transmission of a parasitic protozoan by a blood-sucking parasite. Later, he clearly differentiated between the bovine and human types of tubercle bacilli. He was the first occupant of the chair of comparative pathology at Harvard, and was eventually appointed director of the Department of Animal Pathology in the Rockefeller Institute. He was elected a foreign member of the Royal Society in 1932.

Two well-known British geologists were born in 1859, namely, Alfred Harker and G. W. Lamplugh. Harker, while retaining his lectureship at Cambridge, was for ten years attached to the Scottish Geological Survey. This period was devoted to mapping the volcanic rocks of Skye and other islands of the Inner Hebrides, and his descriptions of these rocks became classics in geological literature. His later more general works on igneous rocks and metamorphism also exerted a lasting influence on petrological thought. He died in 1939, six months after the celebration of his eightieth birthday. G. W. Lamplugh had his first geological paper, on glacial drift in Yorkshire, published when he was only nineteen. He joined the Geological Survey in 1892, and during the next five years completed almost single-handed the mapping of the Isle of Man. Afterwards he carried out an extensive examination of the Irish glacial deposits. He retired from the Survey in 1920 and died six years later. Both Harker and Lamplugh were Fellows of the Royal Society and each had occupied the presidential chair of the Geological Society.

A rather controversial figure in the history of science is that of the Russian physicist, A. S. Popov (1859–1905), a pioneer in the field of radio telegraphy, whose success in signalling has been claimed as antedating that of Marconi. Others born in 1859 include the organic chemists, J. B. Cohen and L. Knorr, the American chemist H. Y. Castner, whose name is associated with the Castner–Kellner process for the manufacture of chlorine and the extraction of sodium, and Florian Cajori, historian of mathematics.

NEWS and VIEWS

Contributions to *Nature*

DURING the first year of the publication of *Nature* (November 1869–November 1870), the number of original communications (mainly "Letters to the Editor", together with some special articles, though not the general ones) was 378. These came from 17 different countries. In certain selected years afterwards, the number of original communications were as follows (number of countries in parenthesis): 1910, 285 (19); 1920, 422 (17); 1930, 568 (27); 1937, 648 (31); 1949, 1,066 (35). During last year (1958), the number of such communications was 2,362, and these were submitted from 59 different countries. These were distributed as follows:

Argentina	2	Japan	80
Australia	128	Kenya	13
Austria	2	Malaya	7
Belgian Congo	3	Mauritius	1
Belgium	41	Mexico	1
Brazil	6	New Zealand	53
British Borneo	1	Nigeria	9
British Honduras	1	Norway	14
British West Indies	11	Pakistan	2
Canada	67	Philippines	1
Ceylon	3	Poland	18
Chile	3	Portugal	1
China	1	Puerto Rico	1
Costa Rica	1	Roumania	5
Czechoslovakia	53	Sarawak	1
Denmark	14	Sierra Leone	3
Egypt	8	South Africa	37
Finland	4	Spain	7
Formosa	1	Sudan	2
France	16	Sweden	44
Germany	25	Switzerland	10
Ghana	4	Tanganyika	3
Greece	1	Uganda	18
Hawaii	5	United Kingdom	959
Holland	48	United States	407
Hungary	24	U.S.S.R. (Russia)	10
India	96	Venezuela	2
Indonesia	1	Yugoslavia	6
Ireland	18	*Total No. of countries*	*59*
Israel	19	*Total No. of communications*	
Italy	40		*2,362*

New Science Officers for American Embassies

SEVEN distinguished scientists have been appointed by the U.S. Department of State to serve as science officers in the American Embassies in London, Paris, Rome, Bonn, Stockholm, and Tokyo. Although assigned to a specific embassy, the science officer will also provide scientific assistance in embassies in adjacent areas. The men selected are: Dr. Thomas H. Osgood, dean of the School for Advanced Graduate Studies, Michigan State University, for London; Dr. Edgar L. Piret, professor of chemical engineering, University of Minnesota, for Paris; Dr. Edward H. Cox, retired head of the Department of Chemistry, Swarthmore College, as deputy science officer for Paris: Dr. Walter Ramberg, chief of the Mechanics Division, National Bureau of Standards, for Rome; Prof. Ludwig F. Audrieth, professor of chemistry, University of Illinois, for Bonn; Dr. Julian E. Mack, professor of physics, University of Wisconsin, for Stockholm; and Prof. Willis R. Boss, professor of zoology, Syracuse University, for Tokyo. The appointments, which will be for a period of two years, constitute the first of a series for the Science Programme of the Department of State under Dr. Wallace R. Brode, science adviser to the Secretary. Still to be appointed are science officers for the U.S.S.R., India and South America, and deputy science officers for all the posts with the exception of Paris, to which Dr. Cox is being assigned. Leaders in science who have had experience as educators, research workers and administrators have been especially selected for these posts because of their international scientific reputation, and their knowledge of the status of science and acquaintance with scientists in the country of assignment. Each of those appointed also has a facility with the language of the country of assignment. A science officer's primary role will be to serve as an adviser to the Ambassador and his staff in the evaluation of the interaction of science with foreign policy, the assessment of current scientific progress abroad and the enhancement of the liaison between United States and foreign scientists and engineers.

British Scientific Attachés Overseas

REPLYING to a question in the House of Commons on December 8 regarding scientific attachés, Mr. G. M. Thomas, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, said that the British Embassies at Washington, Paris, Bonn and Stockholm had a scientific attaché on their staff. The choice was now being made of a suitable person for scientific attaché to the British Embassy in Moscow and the appointment of scientific attachés to certain other embassies was under consideration.

Department of Scientific and Industrial Research : New Five-Year Plan

MR. HARMAR NICHOLLS, Parliamentary Secretary to the Ministry of Works, speaking on behalf of the Lord President of the Council, announced in the House of Commons on December 19 that expenditure on research by the Department of Scientific and Industrial Research will be nearly doubled in the next five years. Under its second five-year plan, for the period 1959–64, approximately £61 million will be made available to the Department, compared with £36 million for the first quinquennium which ends on March 31. By 1963–64 expenditure is planned to reach about £14 million, excluding the British contribution to the European Organization for Nuclear Research (C.E.R.N.) which will continue to be financed outside the five-year plan. The largest expansion will be in university grants. Postgraduate awards will be increased by about 10 per cent each year, until in 1963–64 some 3,800 students will be receiving grants from the Department for research, and support for special research in universities will amount to £1¾ million per annum.

In support of additional research carried out in the Department's own laboratories, expansion of staff at the rate of about 6 per cent per annum is included in the plan. Grants to the research associations financed jointly by the Department and industry will also be increased to more than £2 million per annum by the end of the period. It is also proposed that the Ministry of Works shall increase its rate of expenditure on behalf of the Department so as to provide buildings and equipment for the increased staff of its laboratories. The works programme includes the provision of a new laboratory at Crowthorne, Berkshire, to rehouse the Road Research Laboratory which at present occupies two separate sites a few miles apart, one at Harmondsworth, Middlesex, and the other at Langley, Bucks. The new Road Research Laboratory will include an experimental road system 3½ miles long.

Public Expenditure on Education

IN written answers in the House of Commons on December 17, Mr. Geoffrey Lloyd, Minister of Education, said that expenditure by the Ministry and local education authorities, excluding capital expenditure, was expected to be about £46 million in the current year, rising to about £57 million in 1960–61. To give maximum maintenance grants to 50,000 additional pupils of sixteen and seventeen at the approved rates would cost about £16 million a year. To reduce all classes to a maximum of thirty by about 1965 would cost about a further £200 million a year, with some £140 million on training additional teachers.

Exchange of Personnel between the Post Office and Industry

ON December 17, the Postmaster-General, Mr. H. Marples, in reply to a question in the House of Commons, said that on January 5, a Post Office administrator and a Post Office engineer would take up temporary appointments with Unilever, Ltd., and two Unilever men would go to the Post Office. The exchange was expected to last about a year, and discussions with another concern were in progress. He hoped the experiment would be a forerunner of a regular interchange of experience between the Post Office and industry and contribute mutual benefit and a better understanding of each others' problems.

Pharmacology at the Royal College of Surgeons

THE Royal College of Surgeons of England has received a gift of £150,000 from Mr. G. A. Vandervell for the endowment of its chair of pharmacology. More than ten years have elapsed since those responsible for the rehabilitation of the College after the Second World War recognized that a Department of Pharmacology should be added to the existing departments of anatomy, pathology and physiology, for without it the education of postgraduates in the basic medical sciences would have been incomplete. A still more important objective, however, was the promotion of research into the action of drugs and other substances used not only by surgeons but also by dentists and anæsthetists, who are represented by faculties within the College. The Department was therefore established six years ago, and has flourished under the able direction of Prof. W. D. M. Paton, whose researches into the chemical mediation of nerve impulses are so well known. He and his assistants have been housed temporarily at the Examination Hall, Queen Square, but will shortly be moving into the new buildings in Lincoln's Inn Fields. Since the College is an independent body and therefore does not receive a direct grant from the University Grants Committee or from any other Government source, the Department has been financed hitherto partly by generous contributions from the chemical and pharmaceutical industries. This donation from Mr. Vandervell, which will endow the chair in perpetuity, is doubly welcome since it comes at a time when the College is facing heavy increases in expenditure owing to the extension of its research activities.

National Lending Library for Science and Technology

THE Department of Scientific and Industrial Research will take over part of the former Royal Ordnance Factory at Thorp Arch, near Boston Spa, Yorks, for the use of the new National Lending Library for Science and Technology. Present proposals indicate that the library will begin operating at Thorp Arch in 1961 and become fully operational during the following year. Existing large single-story buildings will be converted into offices and bookstores, and the site provides adequate room for expansion in the future. The new library—the nucleus of which already exists in the Department's Lending Library Unit now at Chester Terrace, Regent's Park, London—will cover all subjects in science and technology, except for some fields of medicine. It will take over the responsibility for the lending service now provided by the Science Museum Library, which in future will concentrate on serving the needs of the enlarged Imperial College of Science and Technology. It is also taking over some of the literature now held by the Science Museum Library. The present Lending Library Unit has been collecting literature for the National Library since 1957. It already operates a loan service for Russian literature which is being progressively extended to cover publications from other countries. Eventually, much of the scientific and technological literature in the world will be included in this collection, to make it the most comprehensive of its kind in the United Kingdom. The new library in Yorkshire will make its unique collection available to research, industrial, educational and other organizations by loans and photographic reproduction. Its primary objective will be to encourage the greater use of scientific and technical literature. One important activity will be the expansion of work on the translation of Russian scientific literature, now organized by the Lending Library Unit in collaboration with the National Science Foundation in the United States. It remains distinct from the National Reference Library of Science and Invention, which it is proposed to establish in London as the successor to the existing Patent Office Library.

International Federation of Operational Research Societies

An International Federation of Operational Research Societies has been created with the objects of developing operational research as a unified science and its advancement in all countries. The initial membership of the Federation consists of the Operational Research Society (United Kingdom), the Operations Research Society of America, and the Société Française de Recherche Opérationnelle. Membership is open to other national societies with the primary object of promoting operational research and with memberships including qualified scientists working in this field. The Federation will be governed by a board of representatives, one representative coming from each member society. According to the statutes, the voting power of each is proportional to the square root of the size of the membership of the Society he represents.

One of the first activities of the Federation will be to sponsor the second international conference on this subject, following the successful first conference held in Oxford in 1957. The second conference is provisionally planned to be held at Aix-en-Provence early in September 1960. Sir Charles Goodeve has agreed to act as secretary and Mr. Donald Hicks as treasurer of the Federation, the address of which is 11 Park Lane, London, W.1.

American Geographical Society Expedition to Chile

The American Geographical Society is sending an expedition to southern Chile for two months study of glaciers in the vicinity of Laguna de San Rafael. Dr. Calvin J. Heusser, of the Society's research staff, will be in charge of the project, which is supported by the Office of Naval Research. Its purpose is to determine the nature and duration of successive phases of climate and vegetation since the glaciers of the last Ice Age receded. The Laguna de San Rafael area was selected because it contains the northernmost glaciers in South America reaching to sea-level and also because its climate, vegetation and physical features resemble those of south-eastern Alaska, where the Society has conducted similar studies since 1948. By correlating the results from Chile with those from Alaska it is hoped that a comparative chronology of climatic variations in the northern and southern hemispheres may be obtained. In addition to Dr. Heusser, the expedition comprises Dr. and Mrs. D. B. Lawrence, both professors of botany in the University of Minnesota; Dr. E. H. Muller, professor of geology, Cornell University; Dr. Carlos Munoz Pizarro, of the Faculty of Agronomy, University of Chile; Shoji Horie, of the Department of Botany, Yale University; and Augusto Grosse, of Puerto Aysen, Chile.

The Atlas Satellite (1958 ζ)

The largest and heaviest satellite so far placed in orbit by the United States was launched in a south-easterly direction from Cape Canaveral in Florida at 23.02 U.T. on December 18. The complete satellite weighs some 8,500 lb., of which only a small proportion, about 150 lb., is pay-load. The remainder of the object is the empty shell of the *Atlas* missile which performed the launching, about 80 ft. long and 10 ft. in diameter. The main purpose of the satellite is to act as a radio relay station, storing and re-transmitting, on frequencies of 132·45 and 139·905 Mc./s., messages sent to it from the ground. It also carries telemetry transmitters operating on 107·97 and 107·94 Mc./s. The satellite is the first to be successfully launched since July 1958, and is designated 1958 ζ. Its orbit is inclined at 32·4° to the equator. Initially, the period of revolution was 101·47 min., and the height varied between 120 and 920 miles, an eccentricity of 0·089; the perigee was near lat. 25° N., when the satellite was on the southward half of its orbit, but the perigee point moved rapidly forward around the orbit, at a rate of 8½° a day. Because its perigee is so low, the life-time of the satellite is expected to be short—only about four weeks.

Giacomo Pylarino (1659–1718)

A pioneer who made variolation a scientific procedure, Giacomo Pylarino was born 300 years ago on January 9, 1659, on the Ionian island Cephalonia. He studied law at Venice and medicine at Padua where he graduated M.D. Practising at Candia in Crete, he made enough money to allow him to travel, and he visited Constantinople, Syria, Egypt, and Smyrna, where he became Consul for Venice. In 1713, Emmanual Timoni, a Greek physician of Constantinople, wrote for the *Philosophical Transactions* an account of the method of variolation as observed and practised by him. Anxious to have further details, Sir Hans Sloane wrote to the British Consul at Smyrna, Dr. Sherrard, who communicated with his former colleague, the Venetian Consul. Pylarino had returned to Venice, but was persuaded to draw up an account of what he knew of the original methods of inoculation at Constantinople during the first years of the century. This was printed at Venice in 1715 under the title "Nova et tuta variolas excitandi per transplantationem methodus; nuper inventa et in usum tracta" and at once copied into the *Philosophical Transactions*. "The most trustworthy account of the Constantinople practice" (Charles Creighton), it dates back to 1701, in which year Pylarino inoculated three children with smallpox virus. He had learned the technique from a Greek woman, but dropped the symbolism, using the skin of the forearm instead of the face at the four points touched in making the sign of the Cross and at the points of the hands and feet pierced by the nails in the Crucifix. It is interesting to note that he spoke of "transplantation" and Timoni of "inoculation"—both figures of speech taken from the gardener's art. Following the publication of Pylarino's description, the Royal Society became really interested in inoculation, and the pages of the *Philosophical Transactions* were filled with further accounts. These were regarded as "virtuoso amusements" (William Douglass) until 1721 when inoculation began to be tried tentatively in London. Pylarino was then no longer living, having died at Padua in June 1718.

City Literary Institute: Science Lectures

A NEW series of lectures sponsored by the City Literary Institute, Stukeley Street, London, W.C.2, and under the auspices of the University of London Department of Extra-Mural Studies, under the general title "Tools of Scientific Discovery: A Review for the Layman and Non-specialist", will begin on January 6, when Prof. G. O. Jones will give an introductory lecture. The other lectures are as follow: "Low Temperatures", Prof. G. O. Jones (January 13); "Radio Telescopes", Mr. Martin Ryle (January 20); "High Temperatures", Dr. R. Latham (January 27); "X-Rays", Dr. H. Judith Milledge (February 3); "Accelerators", Prof. J. Rotblat (February 10); "Isotopes", Prof. J. Rotblat (February 17); "Rockets", Prof. H. S. W. Massey (February 24); "Computers", Dr. R. A. Buckingham (March 3); "Television Techniques", Prof. J. D. McGee (March 10); "Electron Microscope", Mr. C. D. Curling (March 17). The fee for the course is 8*s*. Further information can be obtained from the Principal of the Institute.

The Night Sky in January

NEW moon occurs on Jan. 9d. 05h. 34m. U.T., and full moon on Jan. 24d. 19h. 32m. The following conjunctions with the Moon take place: Jan. 5d. 11h., Jupiter 2° S.; Jan. 18d. 23h., Mars 5° N. In addition to these conjunctions with the Moon, Mercury is in conjunction with Saturn on Jan. 11d. 04h., Mercury being 0·7° S. Mercury is too close to the Sun for easy observation. Venus is an evening star, visible low in the south-west for a short time after sunset. It sets at 18h. 25m. on January 31; its stellar magnitude is − 3·3. Its distance decreases during the month from 170 to 159 million miles. Mars is moving eastwards among the stars and is in Aries throughout January. It sets at 3h. 55m., 3h. 20m. and 2h. 46m. at the beginning, middle and end of the month, respectively. Its stellar magnitude decreases from − 0·6 to + 0·3, its distance from the Earth increasing from 68 to 94 million miles. Mars is in an excellent position for observing during the evening. Jupiter rises at 4h. 25m., 3h. 40m. and 2h. 45m. on January 1, 15 and 31 respectively; it is in Libra. The stellar magnitude of Jupiter is − 1·4; conditions for observation are not very favourable. Saturn is a morning star in Sagittarius, rising at the end of the month at 5h. 30m.; it is too close to the Sun for easy observation. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Jan 1d. 05h. 08·8m., υ Leo. (*D*); Jan. 1d. 05h. 31·2m., υ Leo. (*R*); Jan. 22d. 22h. 09·8m., 26 Gem. (*D*); Jan. 26d. 03h. 04·9m., 6 Leo. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Quadrantid meteors are active on January 3; the radiant is near R.A. 15h. 28m., Dec. + 50°. The Earth is at perihelion on January 2, its distance from the Sun being 91·4 million miles.

Announcements

SIR HENRY DALE has been elected an honorary member of the Biochemical Society. Sir Henry is one of the original members of the Society, and the appointment to honorary membership marks not only his distinction as a scientist but also his many years of service to the Society.

MR. EDMUND J. COOPER, who has had extensive experience of the development of voluntary associations, has been appointed general secretary of the Scientific Film Association.

MR. W. A. FERGUSON, of the Director's office of the British Museum (Natural History), has been appointed secretary of the Museum in succession to Mr. T. Wooddisse, who will retire on reaching the age limit on April 1.

THE Institution of Mining and Metallurgy is to make grants in 1959 from the Bosworth Smith Trust Fund to assist postgraduate research in metalliferous mining (excluding mineral dressing but including surveying and geophysical prospecting). Projects may be supported for more than one year. Forms of application can be obtained from the Secretary, Institution of Mining and Metallurgy, 44 Portland Place, London, W.1, before February 28.

THE Council of St. John's College, Cambridge, proposes not later than the end of April 1959 to make an election to the Kenneth Craik Research Award for the assistance of persons engaged in postgraduate research, preferably in physiological psychology. The value of the Award will be £450 a year. It will be tenable from October 1, 1959, for such period, not less than one year nor more than three years, as the Council shall decide. Applications should be sent to the Master, St. John's College, Cambridge, so as to reach him not later than March 14.

THE Bradford Chemical Society, in conjunction with the Department of Chemical Technology of the Bradford Institute of Technology and the Yorkshire Council for Further Education, is holding a symposium on "Radiation Chemistry" on February 13 and 14 at the Bradford Institute of Technology, Great Horton Road, Bradford 1. Further information can be obtained from Dr. W. R. Moore at the above address.

THE British Polarographic Research Society, 55 Oriental Road, Woking, Surrey, is organizing an intensive five-day course in polarography, to be held during January 12–16. Instruction in techniques will be given by specialists from the Technical Advisory Panel of the Institute. Further details can be obtained from the Secretary of the Institute.

THE NUFFIELD FOUNDATION

REPORT FOR 1957–58

IN its thirteenth annual report, covering the year ended March 31, 1958, the Nuffield Foundation records that, of the £8·5 million distributed during the fifteen years of its existence, about £6·5 million has been expended on ventures within the United Kingdom and £2 million in the overseas Commonwealth, of which grants totalling £850,000 were allocated in the year covered by the report. Of this total, about £1·75 million has been in the fields of science and technology, about £1·5 million in that of medicine, more than £1 million on the care of old people and research in aging, and about £1·25 million on social research and experiment and education. The present report places more emphasis than usual on the Foundation's interest in ventures designed to discover the facts relevant to human behaviour and relationships, and an outstanding illustration of this is the investigation into techniques of sampling and questioning which has been in progress since 1949 under Prof. M. G. Kendall at the London School of Economics. The Foundation has now made a grant of £35,000 over five years to enable the Unit to expand its work to include studies of the design of questionnaires, the validation of social inquiries, of interviewer–respondent bias and the motives behind the actual behaviour of people.

During the year the Foundation sought the views of leading biologists on the emphasis of its biological policy at a week-end conference at Tunbridge Wells, and the Foundation afterwards decided that biology should remain a major interest, not only because biological research is making its expected contributions to medicine and agriculture, but also because it is indicating the growing points in other disciplines, particularly chemistry. Accordingly, the Foundation will support work which promises to lead to a new understanding of biological processes, and the report refers particularly to the Foundation's interest in new developments in the analysis of synthetic systems, the control of enzymic synthesis, and the sequence of events that link particular nuclear components with the organization of the cell. In psychiatry it is interested in studies of behaviour and learning that throw light on the mechanisms involved, and it will continue to be interested in instrumentation, both for resolving existing biological processes and for the possible development of new techniques.

In accordance with this policy, a major grant of the year was £34,000 for the construction of an analogue computer at University College, London, resembling the nervous system of an animal, which will be trained to recognize shapes held in front of its model eye. The new computer, which is the outcome of Prof. J. Z. Young's work on the physiology of learning, should be able to simulate the learning of the alphabet and the numerals and a limited number of more complex shapes, which might include human faces. The Institute of Experimental Psychology, University of Oxford, has also received a grant of £10,000 over three years and nine months towards Dr. N. S. Sutherland's investigation of the mechanisms by which animals and human beings analyse stimuli and, in particular, how visual shapes are analysed. Two grants of £1,980 over three years and £900 over three years were made for investigations at the University of Reading on the structure of optic ganglia of the locust and their connexions and on the brain of the wood ant. A grant of £2,800 over two years was made towards Dr. K. E. Machin's work on physical aspects of behaviour, and a grant of £1,500 a year for two years to University College, London, was in support of three studies which are part of general research into the causes and treatment of mental deficiency: the search for rare or hitherto unknown cases of metabolic disturbance; dietetic experiments with selected amino-acids in cases of metabolic anomaly; and clinical trials of biologically active substances.

A grant of £15,000 over five years was made in support of Prof. B. Katz's work at University College, London, on nerve cells and muscle fibres, and further support of up to £1,500 a year for three years is being provided for Prof. J. Baddiley's work at King's College, Newcastle upon Tyne, on the chemical structure of bacterial cell walls. A programme of research into the effects of radioactive fall-out on wild animal population being undertaken by St. Bartholomew's Hospital Medical College is being supported by a grant of £3,200. A grant of £4,884 over three years was offered for a study of hybrid vigour at University College, London, and £800 a year for two years towards one of the acetate metabolism by *Chlorella*.

Towards Dr. J. D. Biggers's work at the Royal Veterinary College, London, on the growth of embryonic bones on chemically defined media, a grant of £3,200 over five years was offered, and one of £6,000 over three years was made to University College, London, in support of investigations on the mechanisms of processes catalysed by enzymes. For studies of pregnancy toxæmia and scrapie and myopathy in sheep at the Nuffield Institute for Medical Research, Oxford, a renewed grant of £7,500 for two years was made, and one of £6,500 over three years for research into the bacteriology of calf diarrhœa at the Royal Veterinary College, London. £12,000 was offered to the Marine Biological Association of the United Kingdom for the complete reconstruction of its aquarium. £2,200 a year for five years was given to the British Trust for Ornithology for a centre to collate, analyse and file the pooled data of bird observatories and to prepare reports. Up to £2,350 over three years was offered to the University of Glasgow for studies on the effects of physical and biological factors on spawning, while two interesting minor grants of £1,000 were made, one to Marlborough College towards the cost of apparatus needed for actual research into the magnetic susceptibilities of materials, and the other to the University of Leeds for the production of a series of films presenting the development of scientific ideas in a form suitable for sixth forms and undergraduates.

Besides administering the Oliver Bird Fund, the Foundation contributes an equal sum for fundamental and clinical research into the causes and cure of rheumatic diseases. Experience of the past four years points to the need for more centres specializing in rheumatism if more rapid progress is to be made.

Two problems in giving effect to such a policy are how to attract more clinicians into rheumatology and how to stimulate the interest of the pure scientist in the study of fundamental problems which may bear on rheumatism. Hope is expressed that work will soon begin on the difficult problems of what controls the behaviour of the fibroblast and what are the enzyme systems involved. Of four new grants in this field during the year, three have been given to centres already supported by the Foundation; the fourth, of £4,000 over two years, was to the Institute of Orthopædics for research on the constituents of cartilage. The controlled clinical trials of cortisone and allied hormones suggest that both prednisone and prednisolone are superior to cortisone in the treatment of rheumatoid arthritis and that there may be some fundamental difference between the action of these two steroids and cortisone. Of other grants for medical research may be mentioned one of £80,000 to endow a chair in child surgery at the University of London; up to £2,000 to the University of Leeds towards the cost of acquiring a Skeggs Leonard type of artificial kidney for comparison with the Merrill type; £2,250 a year for three years and a capital grant of £300 to the Institute of Neurology, University of London, for a long-term clinical investigation into the effects of hypotensive drugs and anticoagulant therapy in the treatment of cerebrovascular disease; a further grant of £10,700 over two years to the Tuberculous Meningitis Unit, United Oxford Hospitals, for research on disseminated sclerosis; up to £12,000 towards the cost of adaptations to the Pioneer Health Centre, Peckham, for a diagnostic centre for local doctors; and £2,520 a year for three years to the Institute of Psychiatry, University of London, for work on cutting the pituitary stalk.

Among the grants for the care of old people and research in aging are one of £2,500 to the National Institute for Adult Education for a comprehensive inquiry into existing educational facilities for the elderly, the use made of them, and the general role of adult education in helping people to adjust themselves to retirement and to continue leading an active life; £3,000 for a pilot study into the economic circumstances of people over retirement age; £2,000 over three years to the University of Exeter for an investigation into the effects of aging on the performance of tasks of varying complexity; and a further grant of a five-year fellowship rising from £1,500 to £1,700 a year to Dr. A. Comfort for his long-term investigations at University College, London, into the aging of fish and the pattern of aging in dogs and thoroughbred horses, which may yield information on the inheritance of longevity and the effects of parental age.

Other grants for social research and education during the year include: £6,850 over three years in support of a study of the social composition of a Lancashire industrial town, which will comprise an analysis of the number and functions of the professional, managerial and administrative groups and their role in the life of the community, and a study of the working-class population and its part in political and associational life and the relation of local to national culture. This study is being conducted by the Department of Social Anthropology and Sociology, University of Manchester.

A brief summary is given of the first part of Mr. J. Trenaman's study of the educational possibilities of radio and television, newspapers and films, towards which a further grant of £500 has been made. Broadcasting and the Press are the only contemporary influences that can reach across a majority of the population to the fringes of the 45 per cent that are resistant to education in its broader sense, and Mr. Trenaman thinks they could do more to stimulate critical thinking.

SCIENTIFIC BASIS OF LAND PLANNING IN THE TROPICS

An inescapable problem of the present-day world is the increasing pressure of population on land resources. Widespread knowledge and practice of death control have overtaken birth control so that, one by one, the countries of the world are experiencing the problem of how to match expanding population with expanding food production. The problem has now hit the Gambia, and in facing it the Gambian Government, perhaps influenced by the salutary lesson of the failure of the poultry scheme, is wisely realizing the fundamental need for a basis of factual knowledge on which to plan its land use and land planning policy. Rather more than a hundred and fifty years ago Britain, faced with the imminent possibility of a Napoleonic invasion, realized the need for adequate maps and set up the Ordnance Survey.

To-day, the far-flung parts of the Commonwealth face crises of many different types, and the Directorate of Overseas Surveys has been charged with the Herculean task of providing at least a skeleton map cover as a basis of operations. The maps the Directorate is producing are for the most part on a scale of 1 : 50,000 and are based essentially on air photographs. At the same time, the air photographic cover provides a wealth of other information, notably that of present land use. There are special reasons for using this information to prepare a series of land use maps* of the Gambia on the scale of 1 : 25,000. The sandy leached soils in the past have been worked on a system of bush fallowing but produce only indifferent crops of sorghum, millet with some cassava and maize and groundnuts as a cash crop, and a little upland rice. With increased population the period of fallow is so shortened that the soils do not recover and the system breaks down. With Government aid, attention has been turned to the clearance of mangrove and grass swamps bordering the Gambia River and the cultivation of their heavy clay soils for rice. This is more revolutionary than it sounds, because, traditionally, the women have cultivated the land; but swamp clearance, construction of bunds and causeways and mechanized ploughing are man's work. The policy has apparently been successful: the reclaimed areas can be pointed out with pride; the old 'hungry season' of March–April seems to have disappeared. Yet rice imports are increasing. Can it be that as new areas are reclaimed, equally large areas of upland are being abandoned ? Unfortunately, there are no map records, and we see here the inadequacy of statistics where a complete shift in cultivation from one part of an administrative unit to another would not appear at all in any statistics of land use. There could, indeed, be no clearer demonstration of the complementary character of cartographic and statistical–economic interpretation of data, or the inadequacy of the latter without the former.

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* Directorate of Overseas Surveys. Gambia Land Use Map, Sheet 12/1: Janneh Kunda. Gambia Land Use Map, Sheet 14/11: Mansa Konko. (Scale 1 : 25,000.) (Tolworth: Directorate of Overseas Surveys, 1958. Obtainable from Edward Stanford, Ltd., 12 Long Acre, London, W.C.2, and the Survey Department, Bathurst, Gambia.) 3*s.* 6*d.* each.

The work in the Gambia has been carried out under the direction of Mr. Martin Brunt, land use officer of the Directorate of Overseas Surveys, working on air photographs coupled with three periods on the ground for vital checking. He used series of photographs taken in 1946 by the Royal Air Force and another series taken in 1956 by Aircraft Operating Co. (Aerial Surveys), Ltd. The fully coloured maps are able to show, therefore, the extension or retraction of rice lands.

It is characteristic of tropical agriculture that the intricate pattern of land use is apt to defeat the cartographer even on large scales. Gambia is no exception. In the two published sheets out of the projected thirty-five sheets for the central Gambia, six colours are devoted to cropland, three being for rice according to the proportion of the land cultivated—the actual plots are too small. The tidal flats show a complex mixture of high and low mangrove and grass marshes with a little 'barren marsh'. On high ground a distinction is made simply between 'woodland', 'fallow bush' and grass.

In due course an explanatory memoir is promised—no conclusions are drawn at this stage. In the meantime, there can be nothing but praise and admiration for all concerned: a far-sighted Government for commissioning a survey and the publication of a factual document in the form of maps which cannot fail to be of permanent value for all time; a technically excellent publication; and a land use officer who understands clearly the problems involved.

A somewhat similar problem in a still more acute form is presented by the island of Singapore. More than a million and a half people are crowded into an area the size of the Isle of Man. The urgent questions are largely those of town planning, but there are patches of land excellent for intensive market gardening, producing much-needed fresh vegetables for the local market; there are light lands with excellent coconut groves; and, though pineapples have been ousted and rubber is being squeezed out, poor soils remain in second growth scrub protecting water supplies. There are swamp lands inviting reclamation, and once again a careful record and understanding are vital. In this case the mapping is being carried out by the University of Malaya. The survey tradition established in the Department of Geography by Prof. E. H. G. Dobby (now of Ghana) is being ably continued by Robert Ho, Paul Wheatley and their team, and the first sheet* out of ninety-four projected on the scale 1 : 6,336 (10 in. to the mile) has just been published for the Singapore Improvement Trust. Some twenty categories of rural land use are shown, and in addition urban land uses are fully delineated. Like the map of the Gambia, this constitutes a factual document of utmost and lasting value. By showing things as they are and then in the explanatory memoir which is in preparation attempting an explanation, we are led away from that dangerous short cut of mapping 'land capability classes' decided so frequently on inadequate knowledge and based inevitably on a subjective judgment with present-day conditions in mind.

L. Dudley Stamp

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* Singapore Land Use Map, Sheet S/49. Singapore Improvement Trust. 1 : 6,336. Field work by Geography Dept., University of Malaya, July 1958.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

REPORT FOR 1957

THE third annual report of the European Organization for Nuclear Research* (CERN) covers the period to the end of 1957 and includes a list of the twelve member States of the Organization; their percentage contributions to the budgets for the years 1957, 1958 and 1959; details of the structure and membership of the council; and a list of the names of the senior staff of the Organization.

During the period under review, the constructional work on both the proton synchrotron and the synchro-cyclotron accelerators and the buildings on the Meyrin site has progressed according to schedule. The 600-MeV. synchro-cyclotron came into operation on August 1, 1957, and already an interesting programme of research under the supervision of Prof. M. Bernardini, the research director of the Synchro-cyclotron Division, has commenced. Details of the construction and testing of the accelerator are given in a separate section of the report. They include the investigation of properties of the internal proton beam; the installation of the several beam-bending magnets; the construction of the final shielding wall to give protection against neutrons; and the fitting of appropriate channels for mesons and neutrons. The Proton-synchrotron Division has passed the design, planning and ordering stage, and has entered upon the active phase of the construction of the machine and of its ancillary equipment. The whole Division, consisting of 165 staff members engaged on the design and construction of the synchrotron and nine Fellows in the research group studying new ways of accelerating particles, is now installed at Meyrin, and the old offices and laboratories at the Institute of Physics in Geneva have been vacated. The first scheme to be studied by the research group was the plasma ring accelerator proposed by Budker at the CERN Symposium in 1956. Both theoretical studies and experimental studies with an air-cored betatron have been carried out. It is expected that the experiments will indicate the general utility of plasma ring discharges as accelerator guide fields.

The offices, laboratories, experimental halls and the ring complex are all finished and occupied by

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* European Organization for Nuclear Research. Annual Report, 1957. Pp. 86 (25 plates). (Geneva: CERN, 1958.)

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the Proton-synchrotron Division, and apart from minor installations and some road work, there remains only the power house, containing the magnet generators, water-cooling apparatus and electrical sub-station for the whole machine, to be completed. Consideration has already been given to the research programme for the 25-GeV. machine, which is planned to become operational in 1960. At an energy of 25 GeV. the usual methods of particle analysis and detection break down, and therefore a preliminary period devoted to the study and development of the necessary large and expensive experimental equipment required is desirable. A short list of nine typical experiments which has been drawn up is given in the report.

Unlike the accelerator divisions of the Organization, the Theoretical Study Division is not bound to follow a construction time-schedule, and its scientific output has already been considerable. It will, however, be greatly stimulated when the experimental groups become fully operative, for then it will enjoy the benefit of obtaining its data at source. The Division is mainly concerned with the investigation of the so-called elementary particles, their number, structure, properties and interactions. The lists of publications originating from the Division, and the colloquia held at the Institut de Physique in Geneva until June 19, 1957, and at the Meyrin site until the end of the year, together with the lectures and colloquia of the Division at Copenhagen, are given in appendixes to the report. The number of members of the Division greatly increased during the year and included senior physicists from non-member countries who were able to pursue their studies in the Organization's laboratories through grants provided by the Ford Foundation.

In the Scientific and Technical Services Division, the main spheres of development of experimental techniques were liquid-hydrogen bubble chambers and electronic evaluation of track photographs. In addition, a health physics section was started, and the Division continued to administer the Scientific Information Service and the Cosmic Ray Research Group.

The hydrogen-liquefying plant mentioned in last year's report was installed in the summer of 1957 and liquid hydrogen was produced for the first time in July 1957. The plant produces about 32 litres per hour. The 10-cm. bubble chamber was completed during the year, and an illustration of it, together with photographs of other equipment, is included in the annual report.

THE AUTOMATIC COMPUTING ENGINE AT THE NATIONAL PHYSICAL LABORATORY

THE Automatic Computing Engine, or ACE, is the latest digital computing machine to be built at the National Physical Laboratory for the use of its Mathematics Division. This new machine, with its increased speed of operation, its larger storage capacity and its many additional functional facilities, is a considerable advance as a computing tool on its predecessors, the experimental pilot-model, ACE, and its engineered counterpart, DEUCE.

It is not easy to assess the speed of a machine from the times taken to carry out the elementary arithmetical and logical operations. This is particularly true of any machine with a high-speed store of less than about 8,000 words, on which many problems will demand the use of the backing-up store. The times taken for a few basic computations probably give as accurate a picture of the overall speed as can be obtained without a detailed study.

(1) The zeros of a polynomial of the 16th degree may be obtained in an average time of 15 sec. Because of the long word-length (48 digits), accurate roots even of very ill-conditioned polynomials of this degree will be obtained. Polynomials of degrees up to about 250 may be found without using the drum-store, though no particular loss in speed results from using the drum on such problems.

(2) A set of simultaneous equations of order 30 can be solved in about 5 sec. Even if none of the coefficients is zero, sets of orders up to 170 may be solved, the time taken varying approximately as the cube of the order but being slightly less for higher orders.

(3) The solution of Poisson's equation, $\nabla^2 V = 4\pi\rho$ on a square with 400 mesh points, may be obtained in about 75 sec. This time is for the direct solution of the finite difference equations and will give values correct to at least ten decimals. After solving one such problem, solutions corresponding to different distributions of ρ may be obtained in about 15–20 sec. each.

ACE is a serial computer in which numbers and instructions have 48 binary digits; the digit-rate is 1·5 million per second, and therefore its word-time or minor cycle is 32 microseconds.

The main working store consists of twenty-four mercury delay lines each containing thirty-two words, circulating in a major cycle of 1,024 microseconds. Rapid-access storage is obtained by using mercury delay lines with capacities of one, two and four words. The backing store consists of four magnetic drums containing a total of 32,768 words.

The ACE instruction specifies a three-address operation of the form '*A* function *B* to *D*', where *A* and *B* are the store-addresses of the operands and *D* is the store-address to which the result of the operation is to be sent. Instructions also specify a further store-address, *N*, from which the next instruction is to be extracted. The time needed to execute this operation (for single-length numbers) is 32 microseconds, and since each operation may be followed immediately by another, a maximum rate of operation of 30,000 per second is possible.

The drum-store, the multiplier and the divider are independent units. These are put into operation by the appropriate instructions and then work independently until they have completed their operation. This feature provides a parallelism of operation, since a multiplication, division, drum-transfer and a series of ordinary operations could be in progress at the same time.

The three-address operation of the machine allows the multipliers and multiplicand to be selected and the multiplication process to be initiated by a single instruction. The product is formed in fourteen minor cycles, that is to say, in 430 microseconds. The division process is similarly specified, and the quotient (rounded or unrounded) is formed in approximately 1·5 milliseconds. The divider also contains an automatic standardizing process for use in floating-point arithmetical operations.

The magnetic drum-store has a total capacity of 1,024 long delay lines, that is to say, about 1·5 million digits. There are four drums each having 256 tracks, each track storing the contents of one delay line. Each drum has sixteen read heads and sixteen write heads, the 256 tracks being obtained by moving the heads as one unit into one of the sixteen discrete positions. Each drum is 6·75 in. long by 5 in. in diameter, allowing a linear digit packing of 100 per in. The drum is driven by a hysteresis motor running synchronously at 12,000 r.p.m. and is phase-corrected so as to rotate exactly once in five major cycles of the machine.

Punched card and magnetic tape equipment will be provided for input and output. The installation will initially consist of two machines: (1) a broadside card reader, running at 450 cards per min.; (2) a broadside card punch running at 100 cards per min. In order to read or punch 80 columns of a card the computer has an 80-digit input dynamicizer and an 80-digit output staticizer.

The ACE has been designed and constructed to allow easy maintenance. Extensive marginal checking facilities are provided and the chassis units are designed to give complete accessibility to all components, valve connexions, etc.

The machine is housed in ten cabinets, each having a cooled air-circulation system. Each cabinet is fitted with a rising door which permits immediate access to all the twenty-four chassis units contained therein. The number of valve envelopes is about 6,000.

J. H. WILKINSON
D. W. DAVIES

THE ADÉLIE PENGUIN

DETAILED observations of the Adélie penguin, *Pygoscelis adeliae*, have been carried out by Dr. W. J. L. Sladen of the Falkland Islands Dependencies Scientific Bureau and the Edward Grey Institute, University of Oxford[*].

The Adélie is antarctic and circumpolar in its distribution, but does not breed north of the South Sandwich Islands and Bouvet Island. It is the most abundant and widely distributed of all the antarctic penguins.

Two rookeries were studied between 1948 and 1951, one at Hope Bay, Graham Land, and the other at Signy Island, South Orkneys. At both of these there survived a small number of birds that had been ringed two seasons before. The only certain way of determining the sex of these penguins, other than by dissection, is to mark breeding birds before egg-laying and to continue observing them during the early part of the breeding season. Casuals and non-breeders cannot be sexed unless marked and recovered breeding in another season.

The diversity in behaviour of a penguin community appears to be due to three factors which are often inter-related: variation among individuals, differences in 'intensity' of behaviour, and differences in age and breeding experience. Emphasis is laid on the differences in age and breeding experience, and some evidence is given from field observations and dissections to show that this is an important factor.

Suggested age-groups divide a population seen at the rookery into five categories: the experienced (established) breeders, the inexperienced (unestablished) breeders, the non-breeders ('wanderers') in adult plumage, the non-breeders in immature plumage (yearlings), and the nestlings.

The established breeders, probably four or five years old and more, come back to their former nest-sites independently of their former mates. Such a bird may 'keep company' with another bird of the opposite sex until its true mate returns.

The unestablished breeders have first to establish themselves and pair off. Their behaviour differs somewhat from that of the established birds, though with some overlap due to individual variations. They often arrive back later than the established breeders, and take up territories on the periphery of the colonies, or fill vacant places within them. They are the cause of most of the fighting. Courtship behaviour is more prolonged, egg and chick mortality higher and breeding efficiency lower.

The non-breeding 'wanderers' in adult plumage are two or three years old and can be seen wandering around the rookery in small parties, and even visiting rocky outcrops up to 1,000 ft. above sea-level far away from the breeding area. Some of them build poor nests, or occupy vacant sites for a short time before moving elsewhere or being turned out by older birds. Of the wanderers which were dissected, some showed undeveloped gonads despite their adult plumage. It is this age-group which, together with some of the unestablished birds, under favourable conditions, occupy new ground and thus extend the range of the species. They will also quickly take the opportunity to fill any gap in the colonies, and may during the re-occupation period occupy territory in anticipation of the following season.

The yearlings, which are easily recognized by their white throats, normally live among the pack ice, but are occasionally seen at the rookery, where they associate with the wanderers. Several were seen building nests in a half-hearted way on the edge of colonies; but, like the wanderers, they never stayed in one place for long.

Describing the displays and postures of the Adélie penguin, Sladen shows that during the first and second fasting periods the ecstatic display is confined to the male, its most important function appearing to be in pair-formation. A lone male by this display can attract a nearby female to its nest. After the eggs have hatched (or should have hatched), it is also seen in females, though on a diminished scale. It is more commonly seen among the younger and unestablished breeders or non-breeders than among the established breeders.

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[*] Falkland Islands Dependencies Survey. Scientific Reports, No. 17: The Pygoscelid Penguins. 1: Methods of Study. 2: The Adélie Penguin *Pygoscelis adeliae* (Hombron and Jacquinot). By Dr. William J. L. Sladen. Pp. i+97+12 plates. (London: H.M. Stationery Office, 1958. Published for the Colonial Office.) 47*s*. 6*d*. net.

The 'bill to axilla' display, here described for the first time, appears to be closely related to the ecstatic and is probably also associated with pair-formation. Its resemblance to one of the attitudes of threat suggests that this display has in it a greater element of repulsion for the same sex and less attraction for the opposite sex than has the ecstatic. A possible relation to nervous strain of the ecstatic and 'bill to axilla' displays in some situations is suggested.

Bowing is believed to be both a posture and a display, and it is suggested that the display is associated with early pair-formation, and is possibly a form of appeasement ceremony.

Both sexes share the duties of nest-building. The Adélie's habit of stealing stones suggests that it serves a useful purpose in distributing stones throughout a colony from the outside towards the centre, thus reducing the necessity for long treks.

The breeding season starts when birds return to the rookeries in September and October and occupy nest-sites. They may have to travel 200 miles or more from their winter quarters, the last stage being over many miles (up to sixty) of rough sea ice. The occupation period is the period from arrival until the last egg has been laid. Evidence is given from marked birds that, once established, Adélies are, on the whole, very faithful to their old nest-sites from year to year, and keep the same mates. Nest-sites are often covered by a foot or more of snow, yet Adélies appear to come back to the same spot.

The normal clutch is two eggs, the interval between the first and second being 2–4 days. If eggs are removed as soon as laid, a third one is sometimes produced. Adélies are single-brooded. The average incubation period (from the day of laying until the chick is completely out) is thirty-five days with a range of thirty-three to thirty-eight days.

The care of the young is divided into three stages: the guard stage when one of the parents is at the nest to care for and feed the chicks while the other is away collecting food; the crèche stage, when the chick is left alone at an age of about 4 weeks and groups with others to form crèches of 100 or more chicks, and, later, the dispersal of the crèches. Evidence is given from a study of marked adults and chicks that parents feed their own chicks in the crèche, feeding others only in exceptional circumstances. There are no adult 'guardians' of the crèches. These two facts are contrary to previous accounts of penguins the chicks of which group together in crèches.

The Adélie's habit of 'keeping company' (that is, the partnership of two birds of opposite sex at a nest-site which may, or may not, lead to the establishment of a mated pair) is believed to have survival value in facilitating the formation of new pair-bonds should the original mate of an experienced breeder fail to return, or return very late.

Most Adélies moult away from the rookeries among the pack ice. The yearlings moult first. Little is known about the winter movements of the Adélie, but the birds appear to stay in the pack ice and visit land in winter only when gales break up the fast ice and bring the pack close to land.

REINFORCED PLASTICS

A CONFERENCE on reinforced plastics, organized by the British Plastics Federation, was held in Brighton during October 22–24. Twenty-four papers were presented, and a morning was devoted to short talks by representatives of industries which use plastic components.

For structural purposes, high polymers in bulk form are inadequate in strength and stiffness. After surface imperfections have been removed by acid polishing, bulk glass has great strength, of the order of 250,000 lb./in.^{2}, but it is structurally unsuitable, because of the ease with which the surface is damaged and because of the low average stress at which cracks are propagated from regions of damaged surface. By subdividing the glass into fine fibres, and bonding these together with a polymer, a useful two-phase structural material is obtained which is readily shaped during manufacture and which has high resistance to the propagation of cracks. The glass fibres are used in the form of rovings, chopped strand mat or woven fabrics. The polymers are usually polyesters or epoxides which have suitable mechanical properties at temperatures up to 150° C. Silicones are used where parts are required to operate at temperatures above 150° C., and they retain useful strength properties up to 250° C.

Typical strength data for polyester glass sheet materials at room temperature are given in Table 1.

Table 1

Reinforcement	Bidirectional glass fabric	Unidirectional glass fabric	Glass mat
Percentage glass by weight	60–65	62–67	30–45
Tensile strength (lb./in.^{2} × 10^{-3})	40–50	78–86	10–24
Young's modulus (lb./in.^{2} × 10^{-6})	1·0–2·8	4·0–5·0	1·0–2·0

Polyester and epoxide resins are first prepared as linear polymers, containing double bonds; at this stage they are viscous liquids. During preparation, water of condensation is removed. The linear polymers are then cross-linked using a monomer such as styrene or dicyandiamide. Cross-linking is achieved with the aid of a catalyst and may occur at room temperature or at an elevated temperature. Little condensation product is produced and little pressure is necessary.

There is at present little knowledge of the nature of the interface between glass and polymers. Glass is normally covered with a film of moisture in which soluble constituents of the glass dissolve. This film may prevent adhesion to the polymer or inhibit polymerization locally. Various finishes, of which vinyltrichlorsilane is an example, are available for application to glass; by reacting with the moisture film, these are thought to become chemically bonded to the silica in the glass, and to present an unsaturated hydrocarbon surface for adhesion to the polymer. The treatment of glass fibres with such finishes yields a more durable plastic under wet conditions, but there is not yet sufficient experience to enable a reliable assessment to be made of long-term durability. At the conference it was reported that a set of unstressed polyester–glass test pieces showed no deterioration in strength after exposure to English weather for two and a half years, and static-water tanks of the same material have now been in use for the same period with little apparent deterioration.

When loaded to higher stresses, test pieces subjected to cycles of wetting and drying and to increase and decrease in temperature show deterioration in properties. Epoxides are generally superior to polyester under such conditions. Further research is necessary to produce a better understanding of the nature of the deterioration.

The behaviour of plastics reinforced with glass under cyclic loading is interesting. Glass alone withstands a cyclic loading for about the same time as it withstands a steady load equal to the maximum occurring during the cyclic loading. This delayed fracture under steady load is known to be caused by attack of the atmosphere. With plastics reinforced with glass, once the adhesion between glass and polymer has failed, atmospheric attack can take place, especially if the polymer has crazed; but deterioration under cyclic loading may also be associated with damage to the glass surface when it slides in the polymer matrix or rubs against another fibre and with local non-uniformity of the distribution of load among the fibres.

Plastics reinforced with glass fail under cyclic loading in a shorter time than would produce failure under static loading of the same intensity. They therefore display a definite fatigue effect as well as delayed fracture. The relatively high resistance to propagation of cracks is shown by cyclic loading tests on notched test-pieces. For a given notch and nominal stress cycle, the number of cycles to failure may be higher for the plastic than for aluminium alloy.

In plastics reinforced with fibre, each fibre contributes to strength and stiffness only in the direction of its length, and it has been calculated that a two-dimensional isotropic mat of fibres should have strength and stiffness equal to one-third of that of the longitudinal strength of an array of parallel fibres. In principle, glass flakes, if of equal breaking stress, should form a sheet material three times as strong and stiff as a material reinforced with fibre. Preliminary experiments with glass flake material reported at the conference showed considerable increase in stiffness, but the expected increase in strength was not achieved, probably because of damage at the edges of the flakes.

Originally developed for aircraft radomes, plastics reinforced with glass are finding increasing application in a wide variety of components. These include boats (including ship's lifeboats), car bodies, bus and railway wagon-tops, translucent building panels, ventilation ducting, tanks for the chemical industry, partitions for aircraft and ships, and jigs and press tools. Their development has been a co-operative effort of physicists, chemists and engineers. Their further development will depend on the invention of stiffer glass, of resins more stable chemically and on research into the mechanism of deterioration and fracture.

C. GURNEY

WHEAT GENETICS

DURING the ninth International Congress of Genetics, held at Bellagio in 1953, a small group of participants resolved to organize in the future special meetings at which the objects, results and techniques of current research in wheat cytogenetics could be discussed, and at which workers in the field could be brought into personal contact. As a result, the first International Wheat Genetics Symposium was held during August 10–15 at the University of Manitoba, Winnipeg, Canada. Some 150 participants from twenty-nine countries assembled to join in the formal sessions and in informal discussions, and to see something of the famous wheat-growing region of Manitoba.

The formal meetings were held under the general chairmanship of Dr. H. Kihara (Japan), who, in his opening remarks, recollected that it was exactly forty years since the correct chromosome numbers of the polyploid series in wheat were determined by Sakamura and by Sax. The intervening years had seen intensive research in the sub-tribe Triticinae, and this work had contributed to making the cytogenetic composition of common wheat, *Triticum vulgare*, better understood than that of any other polyploid species. Among the themes of the symposium were some of those which have been most prominent over the years in wheat cytogenetics, notably the investigation of the inheritance and the utilization of disease resistance, the study of the genetic make-up of wheat using aneuploids and the study of interspecific crosses.

In distilling the essence of many years of research into the application of backcrossing to plant breeding, and particularly to breeding for disease resistance, Dr. F. N. Briggs (United States) emphasized that these methods could only be applied when suitable recurrent parents were available and where improvement was required over only a limited sector of the total range of genetic variation. Combination of backcrossing with any other method, although sometimes necessary, meant departing from the security of a tested genotype.

Backcrossing is being used by Dr. N. E. Borlaug (Mexico) to produce multi-line varieties of wheat designed to combat stem rust, the biggest single disease hazard to world wheat production. Numbers of different rust resistant parents are backcrossed into a common, generally useful, but rust susceptible, recurrent-parent variety. When the recurrent variety has been reconstituted in each backcross line to such an extent that there is little difference between them, except the source of their disease resistance, seed of the lines can be mixed in various proportions to form multi-line varieties. Since the multi-line variety includes several genetically distinct types of disease resistance, it is likely that during a rust attack some of its component lines will be resistant to the prevalent races of the pathogen. The risk of catastrophic crop failures will therefore be minimized, both on account of the yield returned by the resistant lines and because the lower proportion of susceptibles will limit the build-up of the epidemic. The actual composition of a variety may be changed from time to time to counteract altered frequencies of rust races, and as many as eight lines may need to be included in one variety. The first trials suggest that even in the absence of disease there may be some advantage in growing the multi-line varieties primarily designed to restrict rust.

The importance of developing the disease resistance, and especially the rust resistance, of the wheat crop was underlined by two further contributions. Dr. D. R. Knott (Canada) has analysed twenty-nine varieties of wheat in which he has discovered seven different genes governing stem rust resistance. Some varieties had no genes for resistance, others had up to four, and moreover the genes differ in the level of resistance conferred and in their dominance relationships. By monosomic analysis, the chromosome on which each gene is carried has been determined, and now each gene is being separately studied, in the absence of all other genes for resistance, in a common genetic background. Dr. Knott's work, in conjunction with information on the spectrum of race reactions due to each gene, permits a more rational approach to the utilization of sources of rust resistance in breeding programmes than has previously been possible.

Indeed, this work comes part way to meeting the wishes of Dr. A. R. de Silva (Brazil), who pleaded for a more precise identification of genetic variation in the host and pathogen as a preliminary to the scientific incorporation of rust resistance in breeding material. He considered that host–pathogen relationships should be envisaged in terms of genes for resistance versus genes of pathogenicity, rather than in terms of rust races versus varieties differing in race response.

In discussing these papers, Dr. E. C. Stakman (United States) proposed that resistance was perhaps not simply attributable to single genes, since it depended on the overall physiology and morphology of the plant. Disease resistance was also among the criteria on which Dr. R. de Vilmorin (France) and Mr. H. C. Thorpe (Kenya) placed considerable value in breeding new wheat varieties for their own areas, but both emphasized that overall suitability of varieties was essential, and that this could not be neglected for the sake of particular characteristics.

T. vulgare is extremely tolerant of many aneuploid conditions in a way which forces recognition of the close genetic relationship between the three genomes of which it is composed. Dr. E. R. Sears (United States) has been prominent among those who have exploited the tolerance of aneuploidy in the cytogenetic analysis of wheat. His work commenced with the development of the twenty-one lines monosomic in turn for each of the chromosomes of wheat. By using the monosomic series in crosses with euploids in other varieties it has been possible to analyse some of the genetic differences between varieties. Additional genetic knowledge was obtained from studies of the nullisomic derivatives of monosomics. The seven homœologous groups of three chromosomes representing the equivalent chromosomes of each of the three genomes of wheat have been established by nullisomic–tetrasomic compensation, and the chromosomes in each genome have been determined by crosses of monosomics to stocks deficient for one or other complete genome. Dr. Sears's monosomic series has provided the basis for extensive aneuploid work in Canada which Dr. J. Unrau (Canada) reviewed. Monosomic series have been developed in more than eight wheat varieties, and some genetic analysis of disease and insect resistance and of certain morphological characters has been accomplished. The genetic breakdown of polygenically inherited characters by aneuploid techniques has now commenced. In the Canadian work the reciprocal exchange of intact chromosomes between varieties is a new source of genetic information, a striking example of which is that the substitution of a particular chromosome pair from another variety may increase the yield of the recipient variety by 50 per cent.

The extent of the genetical duplication, or triplication, in hexaploid wheat was stressed from results with induced mutations in diploids, tetraploids and hexaploids by Dr. J. Mac Key (Sweden) and by Dr. S. Matsumura (Japan). This underlined the pronounced triplication of genetic material which is indicated by the recognition of the homœologous groups by nullisomic–tetrasomic compensations. A puzzling problem has been to reconcile genetic triplication of this order with the purely diploid form of meiosis found in *T. vulgare.* However, Dr. R. Riley and Dr. G. D. H. Bell (England) were able to present evidence, confirmed by Dr. Sears, that the cytologically diploid behaviour of hexaploid wheat is controlled by genes on one chromosome, in the absence of which there is pairing between equivalent, homœologous, chromosomes of the different genomes. Thus, genetical triplication in hexaploid wheat can be associated with high fertility and genetical stability because of a genotype which imposes a bivalent-forming regime.

Aegilops squarrosa, the species which contributed the *D* genome of *T. vulgare*, would not be chosen by most plant breeders as a parent in a breeding programme. Yet its chromosomes are undoubtedly present in common wheat; a circumstance which Dr. L. Shebeski (Canada) considers may limit the advances to be made by breeding within the species. Consequently, he and Dr. B. C. Jenkins are producing entirely new sets of seven chromosomes, less restricting in gene content, to replace the *D* genome. The very vigorous amphiploids between tetraploid wheat and rye were made with similar objects by Dr. E. Sanchez-Monge (Spain), and their derivatives may have practical value in certain marginal environments where rye is at present the only suitable cereal crop.

The difficulties of handling the concepts of genome analysis were described by Dr. H. Gaul (Germany), and other considerations in the study of polyploids were discussed by Dr. R. Riley and Dr. G. D. H. Bell (England), who compared the behaviour of a range of synthetic amphiploids with that of related natural polyploids. This work includes studies on the cytogenetics and breeding value of lines in which single pairs of rye chromosomes are added to the full complement of wheat chromosomes, or in which a single pair of wheat chromosomes is replaced by a single rye pair.

The conservation of natural variation in an economically prominent group like *Triticum* is clearly an important consideration, and the maintenance of collections of varieties potentially useful in breeding programmes was described by Dr. J. B. Harrington (Food and Agriculture Organization, Rome) and by Dr. L. P. Reitz and Dr. D. J. Ward

(United States). However, as Dr. A. T. Pugsley (Australia) pointed out, no system was in existence to co-ordinate the maintenance of wheat material of experimentally determined genetic constitution, and one of the practical accomplishments of the symposium was the formulation of a scheme to do this.

A useful session dealt with the application of the induced mutations to plant breeding, during which Dr. R. S. Caldecott (United States) considered the control of the mutation process.

The symposium illustrated the general realization that if the maximum benefit is to be obtained from common wheat which, with rice, is one of the world's most important food crop plants, the fullest understanding of its genetic architecture will be necessary. Already, however, the cytogenetic structure of wheat is better known than that of any other polyploid species, so that work on wheat is profoundly influencing general ideas on evolution by polyploidy and on the genetic functioning of polyploid organisms. The present position has resulted from combining the efforts of many workers over the years. Future progress will similarly be achieved by the accumulation of numerous individual contributions, and so will be most rapid and efficient if the people engaged are enabled to pool their ideas in the way which was possible at the first Wheat Genetics Symposium.

RALPH RILEY

INDIUM MONO-TELLURIDE

By H. C. WRIGHT and J. C. BRICE

Mullard Research Laboratories, Salfords, Surrey

SOME preliminary work has been carried out on the mono-telluride of indium. This revealed some anomalous properties of the compound, which is variously reported as semiconducting[1] and metallic[2]. The compound was prepared by direct fusion of stoichiometric amounts of the elements in sealed evacuated silica tubes. X-ray powder patterns of the compound showed only the lines reported by Schubert[3].

The resistivity and Hall coefficient were measured on four specimens at room temperature. They all showed a carrier density of 10^{18} holes cm.$^{-3}$ or more, and resistivities varying from 4×10^{-3} to 4×10^{-2} ohm cm. In an attempt to change the carrier type, specimens were prepared with 4 atomic per cent excess of each of the elements, respectively. The sign of the thermoelectric power of both these suggested *p*-type conduction.

The temperature coefficient of resistance was metallic from liquid nitrogen temperature to 440° K., at which point an anomaly was observed (Fig. 1). These measurements were made with increasing temperature. On cooling, the resistance at any given temperature was found to be dependent on time. This was investigated by holding a specimen at 463° K. for 16 hr. and cooling over a period of 15 min. to 358° K. The rate at which resistance at time t (R_t) approached its equilibrium value (R_∞) is shown in Fig. 2. It was found that measurements could be repeated provided adequate time for relaxation was allowed.

The thermal electromotive force was measured against copper, using an apparatus described elsewhere[4]. It varied from $1 \cdot 5 \times 10^2$ μV. °K.$^{-1}$ at 300° K. to $2 \cdot 2 \times 10^2$ μV. °K.$^{-1}$ at 580° K. without anomaly. A point-contact diode of the material showed no rectification for currents up to ± 100 m.amp.

Differential thermal analysis was carried out with a standard Gallenkamp apparatus using equal parts of tellurium and silica as a reference material. The results of two runs taken between 370° K. and 530° K. are shown in Fig. 3.

The thermal conductivity of the material was measured by holding one side of a thin disk at the ice point and the remote side in contact with a heated surface at temperatures varying from 290° K. to 490° K. The rate of heat transmission through the disk was deduced from measurements of the power necessary to maintain the heated surface at a given temperature θ with and without the disk in position. Each temperature was maintained for 15 min. These results are presented in Fig. 4 in the form of a graph of WL/A against θ, where W is the rate of heat transmission through the disk of thickness L and cross-sectional area A : the slope of this graph at any temperature yields the thermal con-

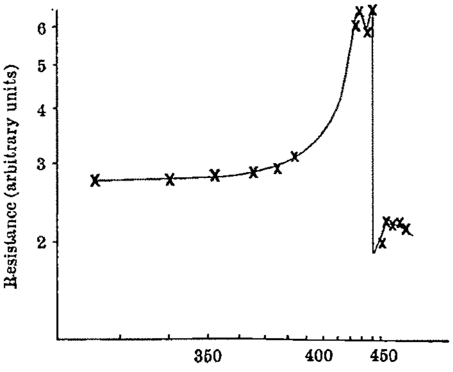

Fig. 1. Resistance versus temperature

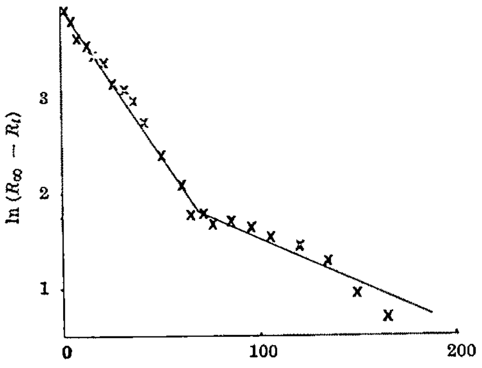

Fig. 2. Change of resistance with time

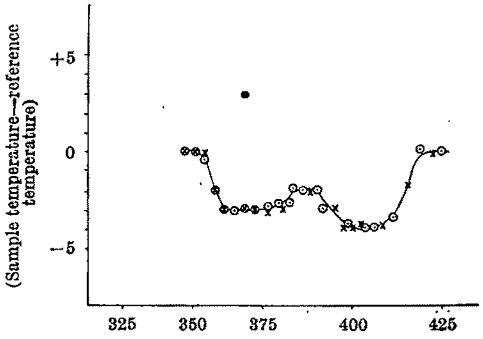

Fig. 3. Results of differential thermal analysis

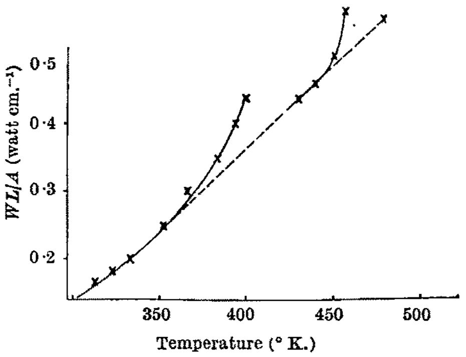

Fig. 4. Thermal conductivity

ductivity of the material at that temperature. This is about 2×10^{-3} joule $cm.^{-1}$ $°K.^{-1}$ except in the two regions between 363–393° K. and 448–473° K., where it is anomalously high.

An optical energy gap was sought by direct reflexion measurements but not found in the range 0·85–2·5μ. Powder reflexion measurements between 0·2 and 1μ yielded no evidence of an energy gap either. A practically constant photo-voltaic effect was seen to be present between 0·85 and 2·5μ. This could be attributed to the junction between the specimen and either of the *Leitsilber* (by Degussa, Frankfort) painted electrodes on it.

The double relaxation time apparent in Fig. 2, the differential thermal analysis result in Fig. 3 and the thermal conductivity graph, Fig. 4, all suggest that two-phase change mechanisms operate between room temperature and 450° K. The resistance/temperature graph shown in Fig. 1 indicates only one change, at 440° K.

Electrical measurements slightly favour a metallic model for the compound in view of the sign of the temperature coefficient of resistance, and the non-rectification of the point contact diode. The large value of the thermal electromotive force, the computed Wiedemann–Franz ratio of 2×10^{-7} $V.^2$ $°K.^{-1}$ at 300° K. and the large variation of resistivity are, however, more characteristic of a semiconductor than a metal.

Much of the preparative work was carried out by Mr. E. M. N. Baldwin and many of the measurements were made by Miss J. Schwarz.

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[2] Mooser, E., and Pearson, W. B., *Phys. Rev.*, **101**, 492 (1956).
[3] Schubert, K., Dörre, E., and Kluge, M., *Z. Metallkunde*, **46**, 216 (1955).
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DOES RHODOPSIN CONTAIN A TRACE METAL?

By ISAO FUKAMI, Prof. BERT L. VALLEE and Prof. GEORGE WALD

Biological Laboratories, Harvard University, Cambridge, Mass., and Biophysics Research Laboratory of the Peter Bent Brigham Hospital, Boston

ONE of the problems involved in the study of the visual pigments is the source of their colour. In rhodopsin, for example, the prosthetic group neo-*b* (11-*cis*) retinene has $\lambda_{\max.}$ in aqueous digitonin solution at about 384 mμ. On combination with the specific protein of the rods, scotopsin, to yield rhodopsin, $\lambda_{\max.}$ is displaced to about 500 mμ. On combination of the same prosthetic group with photopsin, the corresponding protein of the cones, $\lambda_{\max.}$ is displaced to about 562 mμ. In the attempt to understand how the combination with protein could induce such large spectral shifts, an analogy has been drawn with the antimony chloride test for retinene[1]. On mixing retinene with antimony chloride reagent, a photosensitive blue product is obtained with $\lambda_{\max.}$ about 655 mμ, shifting within 30–40 sec. to 664 mμ. Meunier and Vinet[2] had suggested that the source of the blue colour in the similar reaction of vitamin A is the passage of an electron from vitamin A to antimony chloride, to form a vitamin A cation; the greatly increased resonance associated with the electric charge introduced into the conjugated system of alternate single and double bonds causes the great enhancement of colour and large displacement of absorption toward longer wave-lengths.

These suggestions raised the question whether opsin might contain a metal ion which acts similarly upon the attachment of retinene.

Morton and his colleagues have made extensive studies of the occurrence of trace metals in eye tissues, including retinas. Copper and zinc were found primarily in the black tissues of the eye, associated apparently with melanin – protein complexes; only moderate amounts occurred in the retina[3]. In cattle, the retina is particularly rich in manganese, but the outer segments of the rods which contain the rhodopsin have less of this metal than the other retinal tissues[4].

The particular problem in the present instance is to determine whether rhodopsin (opsin) itself contains a trace metal, and for this, of course, it is necessary to remove all contaminating ions. The de-ionization of solutions with ion-exchange resins is now a well-known procedure. Ordinarily, such resins induce

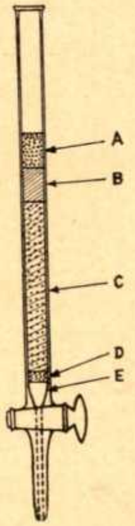

Fig. 1. Arrangement of mixed ion-exchange resins modified from Dintzis (ref. 5). The resins were mounted in a burette in the following order: (*A*) 2 ml. of 'IR-120' in the ammonium cycle form; (*B*) 2 ml. of 'IRA-400' in the acetate cycle form; (*C*) 10 ml. of a mixture of 14 volumes of 'IR-120' in the hydrogen cycle form and 36 volumes of 'IRA-400' in the hydroxyl cycle form; (*D*) about 0·2 ml. of 'IR-120' in the hydrogen cycle form; and (*E*) a plug of glass wool. Both resins employed were the standard 9–10 per cent cross-linkage, 20–50 mesh (Rohm and Haas)

sufficiently high alkalinities or acidities to denature proteins, but Dintzis[5] has devised a combination of resins, variously treated, which avoids this difficulty. Recently, Albrecht[6] used a column of such mixed-bed ion-exchange resins to remove ions from solutions of cattle rhodopsin, and found that this treatment, while removing inorganic ions and small-molecular peptides, does not alter the absorption spectrum of rhodopsin or its regenerability after bleaching.

In the present experiments the same procedure was used to prepare ion-free cattle rhodopsin. All operations were carried out in red light to avoid bleaching. Rhodopsin was prepared from the outer segments of cattle rods, separated from the remaining retinal tissues by differential centrifugation, and pre-extracted with aqueous buffer and petroleum ether, as previously described[7]. At a late step in preparation the buffer solution used to wash the rod residues was replaced by ion-free water to remove the bulk of the salts. The rhodopsin was then extracted with 2 per cent digitonin solution. Its purity was estimated optically through the ratio of extinctions at 400 and 500 mμ (E_{400}/E_{500}); the lower this index, the purer is the preparation. Pure cattle rhodopsin has E_{400}/E_{500} about 0·22. The concentration of rhodopsin was determined from its known[8] molar extinction coefficient at 500 mμ, namely, 40,600.

The design of the resin column is shown in Fig. 1. The column was held for at least one hour at 4° C., and then washed by running ion-free water through it at the same temperature. Since the cattle rhodopsin is dissolved in 2 per cent digitonin solution, this was the eluent used in the procedure. Ion-free digitonin solution was prepared initially by passing 2 per cent digitonin over the mixed bed of resins represented at *C* in Fig. 1. After this treatment the digitonin solution had an electrical conductivity less than $5 \cdot 0 \times 10^{-6}$ mho.

About 15 ml. of such ion-free 2 per cent digitonin was first run through the column at a rate of flow of 0·5 ml./min. Effluents were collected in 3-ml. aliquots. Usually the fourth fraction was set aside as the control digitonin solution for the metal analysis. At the moment when the last of the digitonin left the top of the column, 4 ml. of rhodopsin solution was pipetted on to the column. When this had entered the column, an additional 15 ml. of ion-free digitonin solution was introduced from a pipette and allowed to run through, always at a constant rate of flow. The effluent samples containing the rhodopsin were identified spectrophotometrically, and through the observation that they possess a slightly higher electrical conductivity than ion-free digitonin solution.

After a first preliminary trial, two further rhodopsin solutions were prepared and purified to the limits of these procedures. Their characteristics are shown in Table 1. The second of these solutions was less contaminated with extraneous material absorbing in the ultra-violet than the first, as shown by the lower E_{400}/E_{500} ratio; and it had also a lower specific conductivity. In both cases the *p*H of the de-ionated solutions was 5·2–5·3, close to the isoelectric point of cattle rhodopsin[9].

The metal analyses were performed at the Biophysics Research Laboratory of the Peter Bent Brigham Hospital in Boston, by methods of quantitative emission spectrography described elsewhere[10]. The samples were ashed at 450° C., and dissolved in 6 *N* hydrochloric acid. Spectral line emission was excited with a high-voltage copper spark; for this reason copper itself was not measured. The spectrograph was a 21-ft. Wadsworth mounting equipped with a grating with 15,000 lines/in. and having a reciprocal linear dispersion of 518 A./mm. Eastman No. 103–0 photographic plates were employed, and the spectral lines were measured and corrected for background emission with a microdensitometer (Jarrell-Ash). The procedure was calibrated with spectroscopically pure chemicals obtained from Johnson Matthey and Co., Ltd.

The results of these analyses are shown in Table 2. For each of them 2 ml. of the preparations described in Table 1 were used. Except for aluminium, small amounts of which apparently are carried into these

TABLE 1. PROPERTIES OF TWO RHODOPSIN SOLUTIONS PURIFIED BY PASSAGE THROUGH MIXED-BED ION-EXCHANGE COLUMNS

(1) Ratio of extinctions at 400 and 500 mμ, a measure of optical purity; (2) extinction at 500 mμ, and below it, in parenthesis, the molar concentration of rhodopsin; (3) electrical conductivity in reciprocal ohms; (4) ratio of electrical conductivity before and after de-ionization on the column; (5) *p*H of the final solution

	1 E_{400}/E_{500}	2 Extinction and (molar concentration)	3 Conductivity (mho)	4 Decrease of conductivity through de-ionization	5 *p*H
Rhodopsin (I)	0·36	1·375 ($3 \cdot 39 \times 10^{-5}$)	$9 \cdot 88 \times 10^{-6}$	1/14·8	5·25
Rhodopsin (II)	0·25	1·85 ($4 \cdot 56 \times 10^{-5}$)	$5 \cdot 95 \times 10^{-6}$	1/29·5	5·25
Digitonin control	—	—	$5 \cdot 0 \times 10^{-6}$	1/2·85	6·3

Table 2. METAL ANALYSES OF RHODOPSIN SOLUTIONS DE-IONATED BY PASSAGE THROUGH A MIXED-BED ION-EXCHANGE COLUMN
In each case 2 ml. of rhodopsin solution was ashed and analysed. Results are expressed as μgm./ml. sample as measured, and in the summary rows the corresponding ion equivalents per litre are given for comparison with the concentration of rhodopsin in moles per litre stated

Sample	Zn	Ni	Cd	Fe	Mn	Cr	Ca	Al	Mg	Sr	Mo	Co	Ba	Pb
Rhodopsin (I) ($3\cdot39 \times 10^{-5}$ mol./l.)	0·8	0	0	0·9	0	0	0	0·3	0	0	0	0	0·02	0
Digitonin control	0·6	0	0	0·6	0	0	0	0	0	0	0	0	0·09	0
Net content (ion equiv./l.)	$3\cdot1 \times 10^{-6}$			$5\cdot5 \times 10^{-6}$				*						
Rhodopsin (II) ($4\cdot56 \times 10^{-5}$ mol./l.)	0	0	0	0	0	0	0·3	1·5	0	0	0	0	0·02	0
Digitonin control	0	0	0	0	0	0	0·19	0·05	0	0	0	0	0·01	0
Net content (ion equiv./l.)							$2\cdot5 \times 10^{-6}$	*					$7\cdot3 \times 10^{-8}$	

0, Not detected.

* The values for aluminium are probably spurious, this metal having entered with the use of alum during the preparation.

rhodopsin preparations through the use of alum to 'tan' the rod outer segments, no other metal ion measured proved to be present in concentrations approaching the molar concentration of rhodopsin. Zinc and iron, found in traces in preparation I, were not detectable at all in the purer preparation II. The latter contained a trace of calcium which did not appear in preparation I. A trace of barium appeared in preparation II, but did not seem at all significant, both because it was negligible in amount, and because in preparation I more barium was found in the control digitonin solution than in the rhodopsin. Copper, as indicated, was not measured because a copper spark was used to excite emission. Of the elements that were measured, it seems clear that none exists in cattle rhodopsin in significant amounts.

These experiments offer no evidence for the participation of a metal ion in the structure of rhodopsin. Probably, therefore, there is no need to invoke the action of a metal ion in attempting to account for the chromophoric properties of retinene in any of the known visual pigments. Another mechanism that has recently been proposed, based entirely on organic structures, appears more likely to account for these properties[11].

This investigation was supported in part by funds from the Rockefeller Foundation and the U.S. Office of Naval Research.

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NEW VARIANT OF HUMAN FŒTAL HÆMOGLOBIN

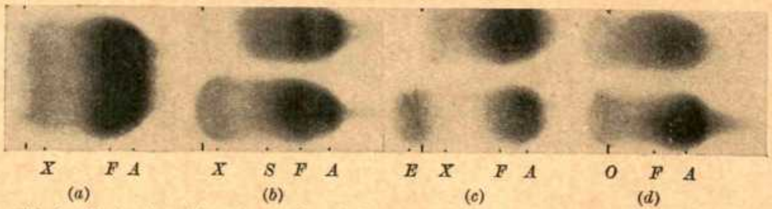
SEVERAL variants of the normal adult hæmoglobin A have been recognized. Furthermore, recent reports[1,2] indicate the existence of variants of the normal human fœtal hæmoglobin F.

In a paper electrophoretic study of the hæmoglobin from newborn infants, one sample (the 140th of this survey), in addition to the usual pattern $F + A$, also contained a smaller component of less anodic mobility than F (Fig. 1*a*). Comparison with known hæmoglobin variants at *p*H 8·0–8·6 disclosed that this component is slower than hæmoglobin S and only slightly faster than E and A_2 (Fig. 1*b* and *c*). At *p*H 6·7 (phosphate buffer, $\Gamma/2$ 0·1) this fraction moved rather like S.

By agar electrophoresis[3] only two spots, corresponding to the positions of hæmoglobins F and A, were obtained. Since this technique is very adequate for the detection of small amounts of hæmoglobins S and C, such as might have been present at birth, the absence of an additional spot anodically to A further excludes the presence of either S or C.

So far hæmoglobin O is the only variant known to occupy a position intermediate between E (and A_2) and S at alkaline buffer[4]. Comparison of the component under study with O disclosed that both are of similar mobility (Fig. 1*d*). Hæmoglobin O, however, can also be demonstrated on agar, where it occupies a position anodically to A (personal communication from Dr. Lie-Injo, confirmed by our comparisons); this property of O distinguishes it from the fraction described here.

Starch electrophoresis at *p*H 8·6 resulted in a pattern similar to the one obtained on paper. Eluates of the isolated fractions were concentrated and sub-



(*a*) (*b*) (*c*) (*d*)

Fig. 1. Electrophoretic patterns, closed-plate apparatus, barbital buffer *p*H 8·0, $\Gamma/2$ 0·05, Whatman No. 3 *MM*, 12 hr., 0·5 m.amp./cm. All strips unstained. Direction of migration, left to right. (*a*) Sample 140, containing fraction X in addition to $A + F$; (*b*) above, artificial mixture containing A, F and S; below, sample 140; (*c*) above, sample 140; below, hæmoglobin $A + E$; (*d*) above, sample 140; below, hæmoglobin $A + O$

jected to electrophoresis again on paper; the slow fraction was very pure, containing only a small amount of *F*. Agar electrophoresis of this fraction revealed only one spot at the position of *F*; such a position of the isolated component can also serve to distinguish it from two other hæmoglobins, which on paper occupy neighbouring places: on one hand *D*, which does not separate[3] from *A*, and on the other A_2, which according to our observations also does not separate from *A* on agar.

The alkali denaturation rate of the isolated slow fraction was measured by a technique adapted from Jonxis and Visser[5]. The rate obtained was similar to that of hæmoglobin *F* from cord blood and to that of the fraction containing mainly *F* of the same electrophoretic separation of sample 140 (Fig. 2).

The ultra-violet spectrum of the fraction under study, following starch electrophoresis of hæmolysates appropriately prepared[6], was very similar to that obtained for hæmoglobin *F* as regards the tryptophan band (Fig. 3).

This sample of cord blood contained 18·3 per cent of the abnormal fraction. Over the ensuing fifteen weeks the abnormal fraction diminished progressively to 2·2 per cent; a parallel diminution of the total alkali-resistant pigment from an initial 60 per cent to 6 per cent was observed.

The newborn presented no clinical or hæmatological abnormality. Of the parents the father was unknown and only the mother was available for study: she was normal.

Our findings suggest that this is another variant of fœtal hæmoglobin: it is similar to hæmoglobin *F* as regards progressive disappearance within the first months postnatally, alkali denaturation-rate, ultra-violet spectrum, and mobility on agar, but definitely distinct from *F* on paper and starch electrophoresis. It is interesting to note that an increased resistance to alkali and an ultra-violet spectrum similar to that of *F* were reported for the fœtal variant 'Bart's'[2].

The possibility should be considered that this variant represents the early normal embryonic hæmoglobin, the existence of which has been suggested by other investigations[7-9]; should this be the case, it must be admitted that in the present instance the early embryonic variant persisted beyond birth. However, the embryonic hæmoglobin of Drescher and Künzer differed from *F* by a definitely faster denaturation-rate[7], while the hæmoglobin of Halbrecht and Klibanski, although slower than *F* on paper, could not be clearly separated from the latter in spite of a prolonged electrophoresis[9]. Furthermore, the mobility of the present fraction was obviously different when compared with hæmoglobin from a 15-week-old fœtus.

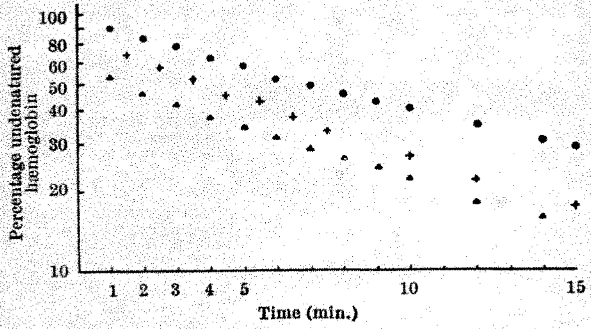


Fig. 2. Alkali denaturation-rate, final concentration of sodium hydroxide 0·05 *M*. Ambient temperature about 30° C. Spectrophotometer Zeiss *PMQ II*, wave-length 576 mμ. +, Normal cord blood; ●, fraction *X* from sample 140; ▲, fraction containing mainly *F* from sample 140

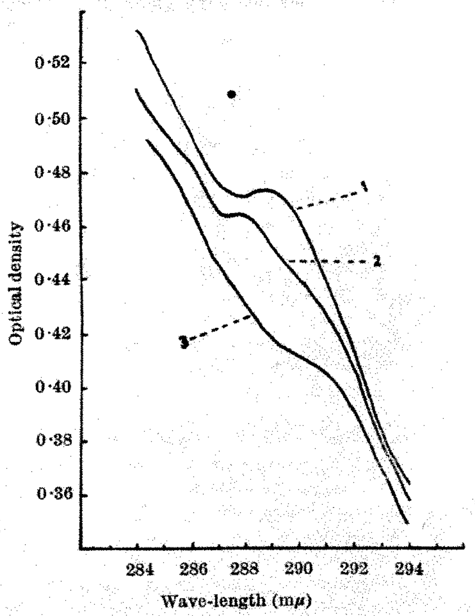


Fig. 3. Ultra-violet spectrum at phosphate buffer, 0·03 *M*, *p*H 6·8, of hæmoglobin solutions. Slit width 0·1 mm., 1 cm. cuvette. (1) Cord blood containing 75 per cent of hæmoglobin *F*; (2) fraction *X* from sample 140; (3) hæmoglobin *A*

The tentative name 'Alexandra' is suggested for the fœtal hæmoglobin described here.

We are indebted to Dr. Lie-Injo Luan Eng, of Djakarta, for supplying samples of hæmoglobin *E* and *O*. We also wish to thank Dr. Gnafakis of the Department of Obstetrics and the staff of the Pædiatric section of the Alexandra Maternity Hospital for helpful collaboration. The Department of Therapeutics, University of Athens, placed at our disposal the spectrophotometer used in this study.

PHAEDON FESSAS
N. MASTROKALOS
G. FOSTIROPOULOS

Hæmatology and Blood Transfusion Service,
Alexandra Hospital,
Athens, Greece.

Oct. 9.

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WHEREAS numerous variants of adult human hæmoglobin (*A*) have been described, there have been few descriptions of hæmoglobins which might be considered variants of the fœtal pigment (*F*)[1,2]. These were concerned with 'fast moving' hæmoglobins, which, on paper electrophoresis at alkaline *p*H, moved towards the anode faster than hæmoglobin *A*. The present report is concerned with a 'slow-moving' component seen in cord blood hæmoglobin collected in Singapore. Usually this pigment is present in very small amounts and cannot be detected with the naked eye, but has to be made visible by drying the paper after electrophoresis and staining it with a protein dye or with benzidine (pseudo-peroxidase reaction). Amounts visible without staining have, however, been found in several Chinese, three Malays, one European (English) and one Eurasian. One sample (Chinese cord blood 675), in which the proportion of this 'slow' component amounted to about 15 per cent of the total hæmoglobin, was suitable for further investigation. The infant had been delivered normally and its weight at birth was 7 lb. 13 oz. Both parents are healthy Chinese living in Singapore and neither of them shows any abnormality of the hæmoglobin on electrophoresis.

On paper electrophoresis at *p*H 8·6, one fraction was seen in the position of hæmoglobins $A + F$, and the other moved more slowly than hæmoglobins S or D, or faster than hæmoglobins E or A_2. On ion-exchange resin chromatography and agar electrophoresis, both using citrate buffer at *p*H 6·2 where A and F can easily be distinguished, the sample separated into two components. The major fraction occupied a position similar to that of hæmoglobin F, and the minor fraction one similar to that of hæmoglobin A_1. The two fractions were eluted, and on paper electrophoresis at *p*H 8·6 it was seen that the major fraction was composed of hæmoglobin F and the new hæmoglobin. Thus on paper electrophoresis at *p*H 8·6 the new hæmoglobin resembles hæmoglobin O, which by this technique migrates between S (or D) and E (or A_2), and on chromatography and agar electrophoresis at *p*H 6·2 it resembles hæmoglobin F and unlike O moves faster than A.

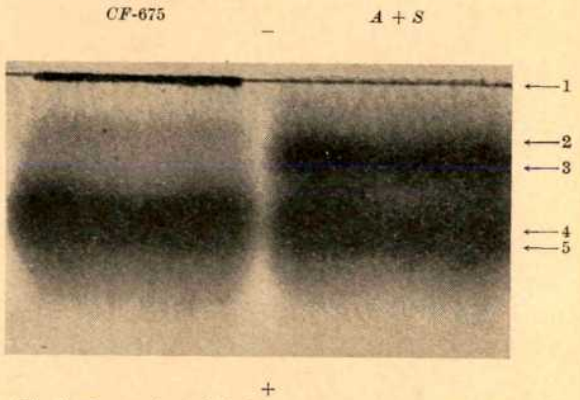

Fig. 1. Comparison of the hæmoglobin from Chinese cord blood *CF*-675 with a hæmoglobin $A + S$ control by paper electrophoresis at *p*H 8·6, hanging strip technique. The paper strip was dried and photographed unstained. (1) Line of application; (2) slow-moving component in *CF*-675; (3) hæmoglobin S; (4) hæmoglobin $F + A$ in *CF*-675; (5) hæmoglobin A

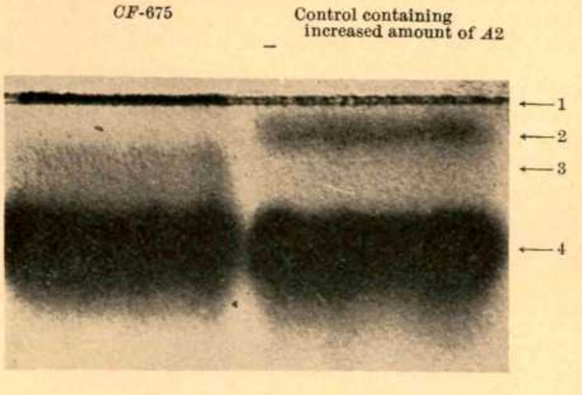

Fig. 2. Comparison of the hæmoglobin from Chinese cord blood *CF*-675 with a control containing hæmoglobins A_1 and F and an increased amount of hæmoglobin A_2. Technical details as for Fig. 1. (1) Line of application; (2) hæmoglobin A_2; (3) slow moving component in *CF*-675; (4) hæmoglobin A_1 (and F)

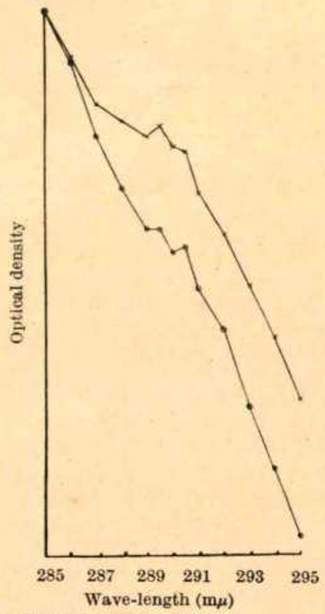

Fig. 3. Ultra-violet spectrum of the slow component isolated from Chinese cord blood *CF*-675 and of purified hæmoglobin from human cord blood containing 80 per cent F and 20 per cent A. ×—×, Cord blood control; ○—○, Chinese cord blood *CF*-675 slow component

It was unfortunate that the hæmoglobin solution had to be transmitted in the carbonomonoxy form and the alkali-denaturation properties of the isolated pigment could therefore not be determined. The ultra-violet spectrum was determined after elution from paper after electrophoresis. It showed a tryptophan fine-structure band of the fœtal hæmoglobin type.

We reported the observation of a slow-moving fœtal component to Dr. Ph. Fessas, who kindly informed us that he had observed a similar or perhaps identical abnormal fœtal hæmoglobin at the Alexandra Hospital in Athens which he proposed to call hæmoglobin 'Alexandra'. As it is very likely that the slow-moving hæmoglobins from cord blood seen in Athens and in Singapore are the same, we have thought it preferable for the time being to refrain from naming the new hæmoglobin described here.

F. VELLA

Department of Biochemistry,
University of Malaya,
Singapore.

J. A. M. AGER

Jenner Laboratory,
St. Thomas's Hospital,

H. LEHMANN

Department of Pathology,
St. Bartholomew's Hospital,
London.

Nov. 11.

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Smoke Emission of Low-Temperature Chars

It has been accepted in the past that coals are effectively smokeless when they contain less than 20 per cent of volatile matter. Thus the approved smokeless fuels include low-volatile steam coals ranging in volatile content from 9·1 to 19·5 per cent and manufactured fuels of volatile content near or less than the lower limit of this range. Consequently, the assumption is sometimes made that, in order to be smokeless, coal products must have their volatile content reduced to less than 20 per cent.

This assumption is unjustified. Early work by Piersol[1] showed that devolatilization of certain American coals gave chars which were smokeless although their volatile contents exceeded 20 per cent. At the Coal Research Establishment a similar effect has been found for high-volatile British coals which were devolatilized by fluidized carbonization. Briquettes made from a char of 33 per cent volatile content emitted less smoke than a steam coal of 18 per cent volatile content, and when made from a char of about 23 per cent volatile content they were completely smokeless.

The smoke emission of a series of chars of different volatile contents and of coals covering a similar volatile range has been investigated. From both coals and chars, the smoke consisted mainly of tar-like pyrolysis products which had escaped complete combustion. The smoke emission decreased with decreasing volatile content, but was always less for a char than for a coal of the same volatile content. Nevertheless, as shown by Fig. 1, a common relationship for coals and chars was found between the smoke yield on combustion and the tar yield as measured by a Gray–King assay. It is concluded that the smoke emission of coals and chars is mainly determined by the yield of tar on carbonization. A char of 23 per cent volatile content is smokeless because its yield of tar is small. This is mainly due to the fact that during the preparation of the char, a considerable amount of tar has already been evolved from the parent coal.

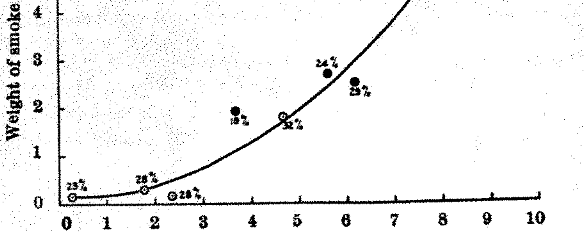

Fig. 1. Relation between weight of smoke and tar yield. Figures adjoining points are volatile matter contents (percentage d.a.f.). ●, Coals; ⊙, chars

Table 1. Yields of Products from the Carbonization of Cannock Wood Coal
(Percentages of dry coal)

Carbonizing conditions	Char	Tar	Liquor	Gas
Coal carbonized to 425° C.	87·7	6·7	3·8	1·4
Char recarbonized to 550° C.	77·8	1·8	4·0	4·0
Total yields from two-stage carbonization	77·8	8·5	7·8	5·4
Coal carbonized directly to 550° C.	76·8	9·8	7·1	6·2

A second factor, however, also contributes to the low yield of tar from a smokeless char. When a high-volatile coal was carbonized at 5 deg. C. per min. to 425° C. to give a smokeless char, the yield of tar was 6·7 per cent by weight. Carbonization of the coal under the same conditions but to 550° C. (a temperature sufficiently high for the maximum yield of tar under these carbonizing conditions) gave 9·8 per cent yield of tar. It might therefore be expected that the yield of tar obtained by carbonizing the smokeless char to 550° C. would equal the difference, namely, 3·1 per cent. The yield obtained (1·8 per cent) was significantly lower. Moreover, as shown in Table 1, the decrease in yield of tar was accompanied by a corresponding increase in the yield of char, the yields of liquor and gas not being significantly affected. These results show that when carbonization is carried out to a fixed upper temperature in two stages, some of the intermediate pyrolysis products, which would have been evolved as tar in a single-stage carbonization to that temperature, are converted into char. This effect is related to the observation of other workers[2-4] who, studying different aspects of coal pyrolysis, have also observed that when the upper temperature limit of carbonization is fixed, the yield of tar or coke depends on the carbonizing conditions. It is concluded that certain pyrolysis products of coal can either be evolved as tar or, if they are left in contact with the heated coal, undergo further reactions—possibly polymerization or condensation—to give a solid product.

Thanks are due to the National Coal Board for permission to publish this communication, a full account of which is being published elsewhere.

W. N. Adams
A. F. Gaines
D. H. Gregory
G. J. Pitt

Coal Research Establishment,
National Coal Board,
Stoke Orchard,
Glos.
Dec. 5.

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Precipitation on a Dislocation

WE have recently made a study of the effect of heat treatment on silicon crystals containing up to 10^{17} aluminium atoms/c.c. After heating for several hours at a temperature of 1,250° C., transmission infra-red microscopy reveals the presence of a precipitated second phase within the crystals. In samples free of dislocations, these precipitates are needle-shaped and located at random sites, whereas in crystals with a dislocation density between 10^3 and 10^4 cm.$^{-2}$, the precipitation occurs almost entirely along the dislocation lines. These latter precipitates invariably appear as discrete particles strung out along the lines (Fig. 1).

A possible mechanism for the growth of the precipitates is suggested by the observation that these are discrete and lie along the dislocation lines, that is, the impurities migrate to the dislocation and then flow rapidly down the core to sites where precipitates have nucleated. Such a possibility has previously been suggested by Bilby[1] to explain the observed persistence of the $t^{2/3}$ law in some strain-aging and internal-friction experiments[2]. Bilby considers that, even in the later stages, the impurities migrate to the dislocation under predominantly drift forces. We consider, however, that the drift flow across any internal surface within the crystal is small compared with the diffusion flow. Such a proposition has recently been used to discuss the growth of an impurity atmosphere near a dislocation[3]. Since the boundary condition adopted in that treatment enforced zero net diffusion flow, the growth of the atmosphere was due entirely to the small drift perturbation.

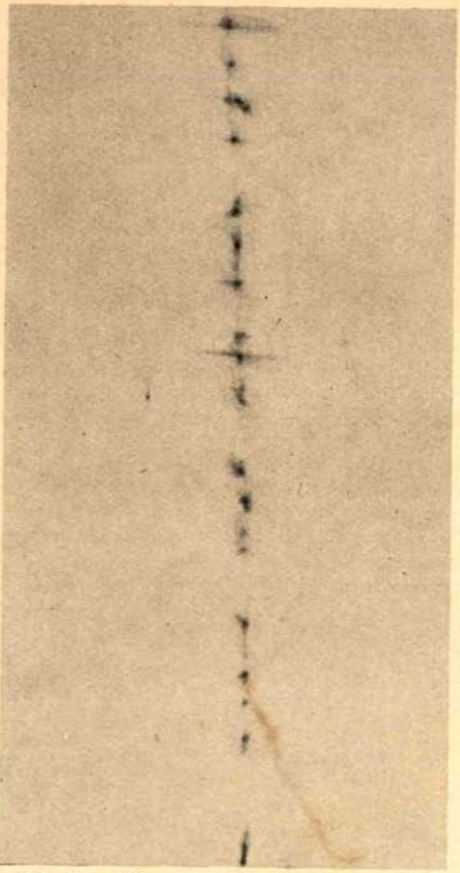

Fig. 1. Discrete particles along an isolated dislocation in aluminium-doped silicon after heating at 1,250° C. for 18 hr. (× 1,000)

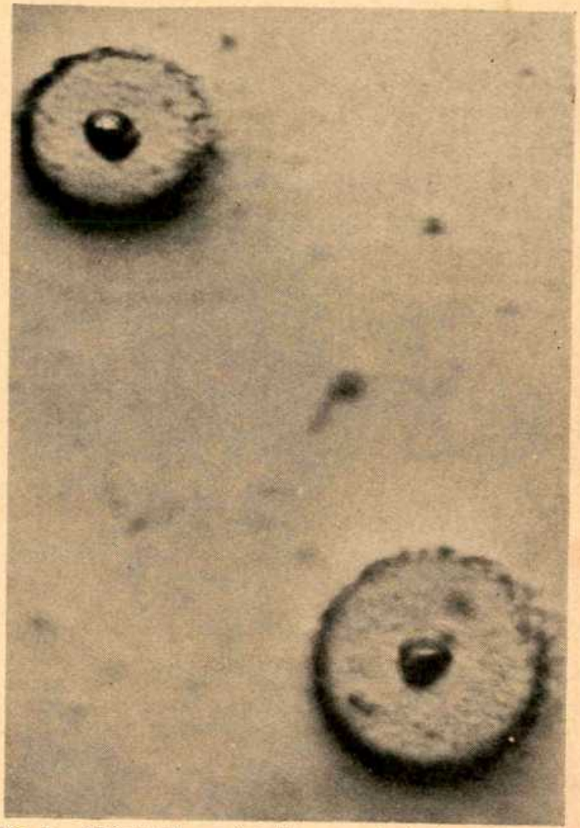

Fig. 2. Cylindrical p–n junction around single dislocations (× 2,200)

An essential feature of our model was that the impurities, in the core region, had extremely high mobility. The concept of high diffusion rates down the dislocation core at a later stage, when the impurity atmospheres have condensed locally to form discrete precipitates, is thus consistent with this model. Once such precipitates have nucleated, the relevant boundary condition is zero impurity concentration at the dislocation core. We assume here that the precipitates occupy only a small fraction of the total length of dislocation line. With this boundary condition, there will be a net diffusion flow across any internal surface, and hence to a first approximation drift flow may be neglected. The number of impurities reaching the core in time t with this boundary condition has been recently evaluated by F. S. Ham (private communication), although his reason for adopting this boundary condition is the opposite of ours, since he considers that impurity atoms are completely immobilized on reaching the centre of the dislocation. The number of atoms arriving at the dislocation in time t is a function of the dimensionless variable $m = Dt/r_0^2$, where D is the diffusion constant and r_0 is the radius of the dislocation core. The variation closely resembles $m^{2/3}$ for $0\cdot 1 \lesssim m \lesssim 20$. It is interesting to note that this variation is similar to that found in strain-aging experiments in steels containing small concentrations of carbon and nitrogen[2]. To obtain reasonable agreement, r_0 must be chosen in the range 20 A. $< r_0 <$ 60 A.; this range includes the value of r_0 obtained in our previous calculation for the growth of a Cottrell atmosphere[3].

If the precipitation process is governed primarily by drift flow, then one would expect an asymmetrical distribution of concentration around the dislocation core, due to the angular dependence of the potential field[4]. Our assumption, however, of the predominance of pure diffusion flow would lead to a radially symmetrical distribution. Silicon provides a unique opportunity to distinguish between these two possibilities. The flow of aluminium (a *p*-type impurity) to form such strings of precipitates as shown in Fig. 1 clearly depletes the region in the neighbourhood of each dislocation. Thus a *p–n* junction would be produced in this region if the crystal initially contained both phosphorus and aluminium, the concentration of the latter being slightly in excess, since no precipitation of phosphorus occurs. The trace of such a *p–n* junction is a line of equal aluminium concentration, and may be revealed as a step on the surface of the crystal by using the Dash etch[5]; at the same time, an etch pit is produced at the point of emergence of the dislocation line. Examples of this are shown in Fig. 2. The *p–n* junctions are seen to be circular and concentric about the etch pits, supporting our argument for radially symmetrical flow to the dislocations. A more stringent test would be to examine this contour after much shorter diffusion times; however, the technique is only feasible when the radius of the *p–n* junction is greater than the radius of the etch pit.

We wish to thank our colleagues in this Laboratory for support in carrying out this work. Thanks are also due to Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, and to the Admiralty, for permission to publish this communication.

R. BULLOUGH
R. C. NEWMAN
J. WAKEFIELD
J. B. WILLIS

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston Court,
Aldermaston, Berkshire.
Dec. 9.

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Neutron Diffraction at a High-Flux Reactor

UP to the present, all neutron diffraction studies in Great Britain and practically all structural studies elsewhere have been carried out with neutron beams from reactors which have a peak flux of a few times 10^{12} neutrons per sq. cm. per sec.; for example, at Harwell the reactor Bepo has been used for this work. We have now made preliminary measurements with a spectrometer at the research reactor Dido, where a peak unperturbed flux of about 5×10^{13} neutrons per sq. cm. per sec. is available. We achieve in practice an increase of about twenty times the intensity of our neutron beam, and this increase is available for reducing proportionately the size of the sample for study. The advantage of this, for solid-state studies with neutron beams, can be seen in two ways.

For materials which are available only in polycrystalline or powder form it was previously necessary to use about 5 c.c. of material in order to attain reasonably large diffracted intensities and adequate angular resolution. The same result is now obtained with a volume of 0·3 c.c. This quantity of diamond powder, often used as a standard substance, has given peak intensities of 560 and 460 counts per min. for the (111) and (220) reflexions respectively on a background of 40 counts. Apart from the more obvious advantages of using small samples, there is an important prospective gain for magnetic materials: it will become a practical proposition to make samples with the iron isotope, iron-57, which has a nuclear scattering amplitude less than a quarter of that of ordinary iron and which is correspondingly less troublesome when distinguishing between the contributions from nuclear and magnetic scattering.

For single crystal investigations, a reduction in size by twenty times enormously increases the range of materials which can be obtained in crystals of sufficient size to be studied. Over the past few years structural studies have been made at Harwell using single crystals of many chemical compounds. The average size of crystal used has been 160 c. mm.; thus this now becomes about 8 c. mm., or a fragment with an edge of about 2 mm. each way. We quote as an example a result for potassium bromide which serves as a standard substance; a cleaved block with a volume of 5 c. mm. gave a peak count of 7,000 neutrons per min. for the (200) reflexion. As well as widening the range of materials which can be studied as single crystals, reduction of size brings the important additional advantages that corrections for secondary extinction will be much less significant, and crystal preparation using selected isotopes, for application of the isomorphous replacement method of structural analysis, will become practicable.

A description of the spectrometer, with an account of the problems posed by the higher flux, will be published elsewhere.

G. E. BACON
R. F. DYER

Atomic Energy Research Establishment,
Harwell.
Nov. 6.

Tensile Strength of Asbestos

ASBESTOS is the generic name for those silicate minerals which cleave naturally into fibres, the three important species being chrysotile (white asbestos), crocidolite (blue asbestos) and amosite. This unique mineral structure lends itself better to measurements of tensile strength than do the more common minerals with isotropic or platy structures, which are extremely difficult to prepare in the form of adequate tensile specimens, although measurements on mica have been reported[1].

Very high values may be predicted for tensile strengths of silicates, from consideration both of the strengths of the stable silicon–oxygen chains or sheets which characterize these minerals, and of the cohesive pressures which exist in solids, and which must be equalized in order to break a specimen. An explanation for the discrepancy, which exists between the estimated tensile strengths of solids and the highest values usually obtained in practice, was given by Griffiths[2,3], who said in effect that the high strengths calculated were correct and that the tensile measurements were wrong. The tensile strength of asbestos has been measured by Syromjatnikoff[4] and by Badollet[5], who have reported various values, but none exceeding 330,000 lb./in.^{2}, which is a high value for a tensile strength (steel piano wire is usually quoted as having a strength of 350,000 lb./in.^{2}), but is only a fraction of the value to be expected.

We have carried out a large number of tensile measurements (including modulus determinations), on asbestos of different types and have found that results may be obtained which are much higher than any yet reported. By taking high-speed photographs during a measurement, we have also been able to demonstrate the type of failure which occurs when asbestos fibres break. Our initial work indicated that, in order to obtain accurate results, the cross-sectional area of the fibres should not exceed 10^{-5} cm.^{2}, this being calculated from the specific gravity, length and weight of the specimens determined on a microbalance with a sensitivity of 1 μgm. The samples were mounted on a slip of paper on two spots of 'Seccotine' and these covered with small squares of paper. In this way, a good grip for the jaws of the tensometer was provided, and there was no tendency for the fibres to slip through the glue. The paper was carefully cut through just before the stress was applied. The tensometer consisted of a modified 'Chainomatic' balance: the strain was determined by observing the pointer with a microscope.

Our investigation consisted of making a series of determinations of tensile strength for various lengths of fibre. Average results, as well as a maximum strength obtained at each length, are shown on Table 1. Each average strength reported is the mean of not less than 25 results, it being found that a larger number of tests did not appreciably alter the progressive average. Tests carried out on the same samples, over a period of two years, gave repeatable results to within a few per cent.

Table 1. TENSILE STRENGTH

Sample	Length of sample (cm.)	Ultimate tensile strength (10^3 lb./in.^{2})		Coefficient of variation (per cent)
		Average	Maximum measured value	
Amosite (Transvaal)	3·5	148	247	34·6
	2·5	146	248	35·0
	1·7	172	269	29·2
	1·0	192	283	32·5
	0·5	203	287	24·7
Crocidolite (Cape Province)	3·5	469	740	29·4
	2·5	470	735	31·3
	1·0	540	815	23·0
	0·5	585	870	24·5
	0·2	605	876	20·3
Chrysotile (Arizona)	3·5	186	314	34·8
	2·2	208	346	34·9
	1·5	236	425	40·0
	1·0	312	470	29·9
	0·5	309	596	34·7
	0·2	320	820	56·8
Chrysotile (Thetford, Canada)	2·5	281	604	34·5
	1·5	321	670	41·0
	1·0	355	704	41·1
	0·5	414	789	33·4
	0·2	436	824	31·3

Table 2. YOUNG'S MODULUS

Sample	Length of sample (cm.)	Young's modulus (10^6 lb./in.^{2})	Coefficient of variation (per cent)
Amosite (Transvaal)	3·5	23·6	8·7
Crocidolite (Cape Province)	3·5	27·1	6·8
Chrysotile (Arizona)	3·5	23·2	9·9
Chrysotile (Thetford, Canada)	2·5	23·1	10·6

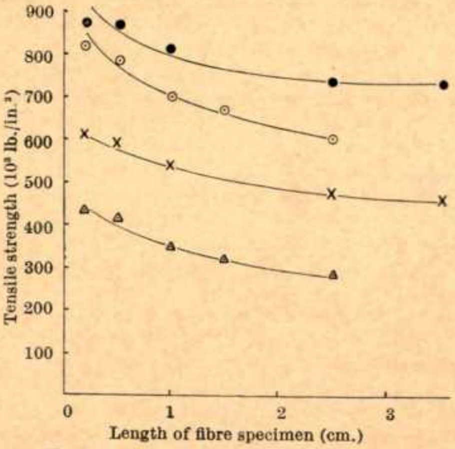

Fig. 1. The observed tensile strengths of Canadian chrysotile (⊙, maximum; Δ, mean) and of South African crocidolite (●, maximum; ×, mean) plotted against length of fibre specimen

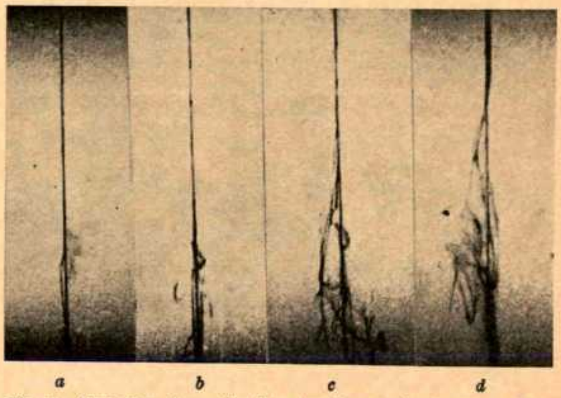

Fig. 2. Canadian chrysotile fibre breaking under tension. The intervals between each of the four exposures are 16·5, 32 and 44 thousandths of one second, respectively

Relatively long fibres were used to obtain values of Young's modulus, which are given in Table 2. For amosite and crocidolite asbestos, the plots of load versus extension were straight lines up to the breaking point. For chrysotile asbestos, plastic deformation occurred when the tensile stress exceeded about 80 per cent of the breaking load; the straight portions of the curves were used for calculating Young's modulus.

The tensile determinations show that in the most favourable circumstances, and using very short fibres, tensile strengths of approximately 900,000 lb./in.^{2} may be obtained, approaching the value of 1,500,000 lb./in.^{2}, which Orowan has suggested[6] for solids of this type (Fig. 1). The photographs (Fig. 2) demonstrate the mechanism of failure during the tests, which is comparable with that of mica, reported by Orowan[7]. Amosite gave a more brittle and sudden fracture which could not be resolved on our photographs.

Thus it appears that failure usually begins at a surface flaw but that the strain is relieved by rupture of the relatively weak interfibrillar bonds, thus producing broken fibres at that point, but exposing the surfaces of fresh fibres which may begin to fail at quite a different place. The possibility of failure beginning at surface flaws is clearly reduced as the length of the specimen is decreased, thus enabling higher tensile strengths to be measured on shorter specimens.

We are grateful to Prof. E. Orowan, of the Massachusetts Institute of Technology, for helpful comments, and to the directors of the Cape Asbestos Co., Ltd., for permission to publish these results.

R. Zukowski
R. Gaze

Central Research Laboratory,
The Cape Asbestos Co., Ltd.,
Harts Lane,
Barking, Essex.

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Simulation of Lunar Craters: a Blow-hole Theory

Recent reports of volcanic activity on the Moon[1] have stimulated us to repeat an accidental observation made many years ago by one of us (A. G. G.). During rapid evacuation of a quantity of magnesium carbonate in a flask, a number of blow-holes appeared as the occluded gas escaped, leaving a pattern of rings, some with central 'pimples', closely resembling lunar craters. In the present work, we have repeated this experiment (Fig. 1). We have also put a quantity of dry powder (sand, salt, magnesium oxide or magnesium carbonate) in a 5-l. flask, which was continuously evacuated; a small flow of air was admitted at the bottom of the flask by a small hole. Various forms of blow-hole were observed. In many cases, a marked ring, with steep inner edge and less steep outer edge, was formed by the fountain of small particles; sometimes, when the air was cut off, a small pimple remained at the centre of the fountain as it collapsed (Fig. 2). The form of the 'crater' varied rather with type of powder, especially its angle of slip, and the depth, and with the rate of flow of gas.

It is known that terrestrial volcanoes may emit large quantities of dust and ash (cf. the fate of Pompeii), but the presence of an atmosphere interferes with the free fall of the particles. On the Moon, with no atmosphere, lower gravity, and probably a dry, 'sandy' surface, formation of the craters, with or without a central peak as the blow-out peters out, seems possible. It should be noted that the escape of gas trapped beneath the Moon's loose 'sandy' surface, with the formation of this type of blow-hole crater, would not necessarily require the high subsurface temperatures usually associated with volcanic activity.

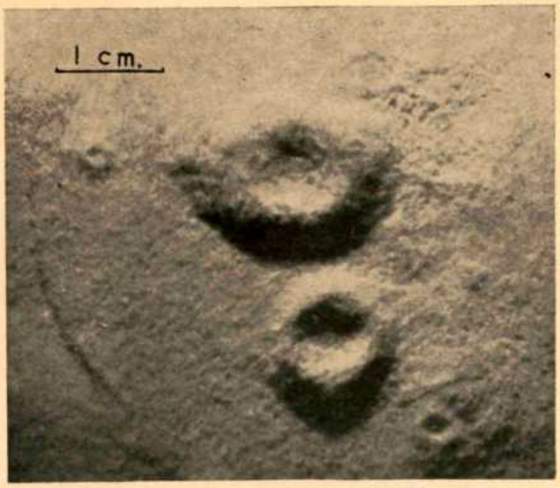

Fig. 1

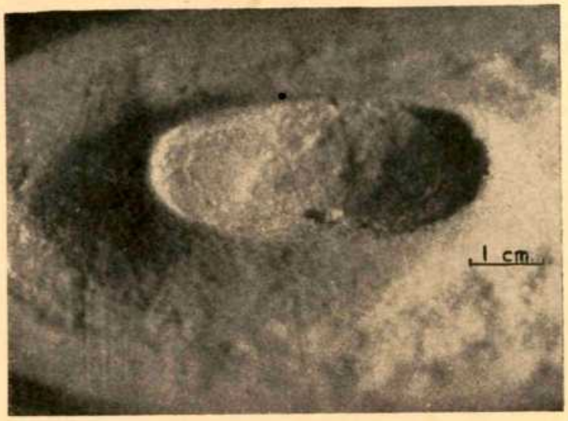

Fig. 2

The meteoric theory of craters seems unable easily to account for the circular, rather than oval, shape made by the non-vertical fall of a meteorite, or for the very smooth surface of the area within the ring. In our experiments, the region within the craters was usually fairly flat, although the formation of a fluidized bed may account for this, and such a condition seems unlikely on the scale of the lunar surface.

Recent unconfirmed reports[1] of C_2 emission bands near the crater Alphonsus may not necessarily indicate that the gas has a very high initial temperature. It has recently been shown[2] that shock-wave excitation of CO, CO_2 or CH_4 produces C_2 Swan emission. Shock-waves can be produced by a sudden release of pressure, as in the bursting-diaphragm shock tube.

While these theories are speculative, it seems that the possibility of lunar craters being caused by fountains of dust blown out by trapped gas should be considered.

A. G. Gaydon
R. C. M. Learner

Department of Chemical Engineering,
Imperial College of Science and Technology,
London, S.W.7. Dec. 5.

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Microwave Dielectric Properties of Indian Shellac in the 8-mm. Range

Shellac is produced in India after refinement from natural seedlac which contains more than 88 per cent of lac and 4·5 per cent of wax, the remainder being made up of colouring matter, gluten and moisture. Various grades of commercial shellac contain varying percentages of soluble impurities, wax, rosin and moisture. For microwave work a very high degree of purity is needed in dielectric samples. The three grades of shellac, 'Blonde', 'Crown' and 'Granta', manufactured by Angelo Bros., are free from rosin and orpiment and contain only 0·5–0·1 per cent of the insoluble impurities.

They are at present the only samples of the highest degree of purity available and have therefore been used for dielectric measurements in the 8-mm. band. Measurements have also been taken in two other electrical grades used for micanite. The dielectric loss in shellac, grade 'Blonde', is found to be the lowest in the 8-mm. band, and for this grade measurements of loss have also been carried out over a very wide band of radio frequencies.

The microwave dielectric properties of several grades of shellac at radio-frequencies have been reported[1] and the variation of the dielectric loss with temperature has also been studied[2] in three grades of shellac of high purity in the 3-cm. band. The loss factor in the case of shellac lies in the medium range so that the standing-wave technique of Von Hippel[3] is found to be most suitable and accurate. A suitable test bench with a *VX* 357 klystron oscillator, an attenuator and a Hilger standing-wave indicator Type *W*870 with frequency meter and crystal detector were used. The oscillator could operate continuously in the range 8·35–9·16 mm. with a maximum power output of 19·5 MW. The unit was situated in an air-conditioned laboratory and additional air cooling was provided by an external assembly of air blowers, to keep frequency-drift to a minimum. A dielectric cell with a movable shorting plunger was made in the laboratory. The square law response of the crystal, depth of probe penetration and standing wave ratio with the shorting plunger were adjusted in accordance with the standard methods[4].

Wave-guide samples of shellac were made by softening the material, obtained in the form of flakes of high purity, and then moulding it in a die under pressure. The die was kept warm, to prevent entrapping of air bubbles, and only samples free from them were used for these experiments. At least three samples of each grade of shellac of varying thicknesses between $\lambda_d/4$ and $5\lambda_d/4$ were used for measurements of loss, where λ_d is the wave-length in the dielectric. All samples were first dried in an electric oven and then left in a desiccator for 45 hr.: it was found that moisture can be eliminated by this method without detriment to the sample.

The complex permittivity $\chi = \chi' - j\chi''$ has been determined at room temperature (25° ± 1° C.) at 35·65 Gc./s. ($\lambda_0 = 8{\cdot}412$ mm.) and the results are shown in Table 1. χ'' is represented in terms of the tangent of the loss angle, $\tan\delta = \chi''/\chi'$. A correction was also applied to the dielectric constant for clearance errors[5].

Dewaxed 'Blonde' grade of Indian shellac shows the lowest loss in the 8-mm. band. This particularly pure grade is made by a solvent process using cold alcohol, in which the wax is soluble. The measurements of dielectric loss in this grade were carried out over a wide frequency band from 10 kc./s. to 35 Gc./s. to find the peak of the dielectric loss. The *S*-band measurements were made on a shorted coaxial line[6] through the courtesy of Shri Krishnaji in the Department of Physics in the University of Allahabad. The tan δ – log f curve for this grade is shown in Fig. 1.

Table 1. DIELECTRIC CONSTANT AND LOSS OF INDIAN SHELLAC IN THE 8-MM. BAND

Grade of shellac	Insoluble impurities	Wax (per cent)	ε' at 25° C.	tan δ 25° C.
'Blonde'	0·1	Nil	2·761	0·0082
'Crown'	0·5	4·5	2·831	0·0379
XL	0·5	4·5	2·790	0·0310
'*C* Pure'	0·5	2·5	2·790	0·0661
'Granta'	0·5	3·0	2·780	0·0751

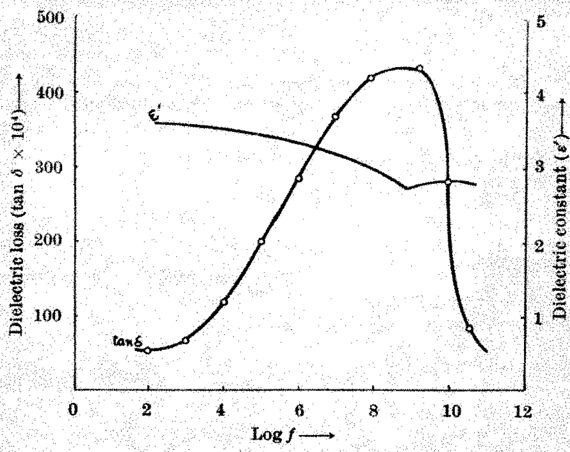

Fig. 1. Tan δ – log f curve of 'Blonde' grade shellac (0·1 per cent)

We are grateful to Dr. K. N. Mathur, deputy director of the National Physical Laboratory, for providing the facilities for this work. One of us (S. S. S.) is also grateful to Dr. D. S. Kothari, scientific adviser to the Ministry of Defence, for permission to work in the National Physical Laboratory.

S. S. SRIVASTAVA
Indian Naval Physical Laboratory,
Cochin.

D. D. PURI
National Physical Laboratory of India,
New Delhi.

Sept. 23.

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CHEMISTRY

Explosion of Transition Metal Co-ordination Compounds

IN a recent discussion on the initiation and growth of explosion in solids, Eggert[1] and McAuslan[2] reported on the initiation of explosions by light. Evidence was presented for the photochemical and/or photothermic effects in various nitrides, azides, acetylides and perchlorates.

During an investigation of the photochemical reaction of some transition metal complexes[3], the compounds $[Co(en)_3]_2(S_2O_8)_3$ and $[Cr(en)_3]_2(S_2O_8)_3$ were prepared as part of a programme to discover possible photosensitive systems among the solid co-ordination compounds of the transition elements. Quite accidentally, it was observed that the chromium compound produced an explosion, accompanied by the formation of a copious ash, when ignited by a flame. A systematic examination of this phenomenon showed that the explosion could also be initiated by exposing the compounds to ultra-violet radiation (3650 A.) followed by heating. The chromium compound exploded at 115° C. and the cobalt compound at 120° C.

While attempting to deduce the mechanism of the photosensitivity of these compounds brought about by ultra-violet radiation and heat, a severe explosion occurred as the chromium compound was being irradiated, and perhaps overheated, in a Vycor tube attached to the mass spectrometer. Further investigation showed that the controlled thermal decomposition following ultra-violet radiation resulted in the oxidation of the ligand with the evolution of nitrogen, carbon dioxide and water vapour.

This work was done at the University of Connecticut, Storrs, Connecticut.

SEWARD E. BEACOM

General Motors Research Laboratories,
Box 188, North End Station,
Detroit 2.
Oct. 31.

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Sealing of Aluminium Oxide Anodic Films

THE formation of boehmite on the surface of anodized aluminium by immersion in boiling water has been investigated by Hart[1]. In particular, studying ammonium borate anodic films on aluminium, he found by electron diffraction that the pseudo-amorphous structure of the surface layer was converted to boehmite, but that this change did not occur when the detached film was immersed in boiling water. Hart therefore suggested that the mechanism of the process was an outward movement of aluminium ions from the metal, passing through the oxide layer, and combining with hydroxyl ions to form boehmite in the pores of the existing oxide layer and on the outer surface.

Similar experimental results were also reported by Kerr[2], again after an electron-diffraction study of ammonium borate anodized films, when it was concluded that boehmite was formed only in the presence of metallic aluminium. Spooner[3], however, making an electron-diffraction study of sulphuric acid anodic coatings, found that conversion of the aluminium oxide layer to boehmite occurred in films attached to, and detached from, their aluminium bases, which confirmed that in this case the process was one of hydration of the existing oxide and did not require the presence of metallic aluminium.

It may therefore be of interest to report that working with boric acid anodic coatings we also found that conversion to boehmite occurs in films, detached from their aluminium bases, when sealed in boiling water.

Aluminium foil (99·99 per cent) of 0·012 mm. thickness was anodized at 550 V. in boric acid solution. After sealing by immersion in boiling water, the anodic film was stripped from the metal using saturated mercuric chloride solution and washed in distilled water. The resulting film was too thick to allow an electron diffraction transmission pattern to be obtained; but it was found that an outer layer, ~100 A. in thickness, could be obtained by evaporating a thin coating of aluminium on to the sealed film while still attached to the foil, and freeing this with a chromic–phosphoric acid solution[4]. An electron diffraction transmission pattern of this exceedingly thin aluminium-supported layer showed the presence of boehmite, the reflexions being compared and found to be in good agreement with published results[5].

An X-ray powder diffraction pattern of the whole film as separated by mercuric chloride, which was carefully wrapped on to a glass fibre, showed a predominantly γ-alumina composition with evidence of only a small amount of boehmite present. In a further study the film was removed from an anodized but unsealed foil, using the mercuric chloride technique, and boiled in distilled water for 20 min. An X-ray powder specimen was prepared as before, and the resultant diffraction pattern again showed the presence of boehmite and γ-alumina. In this case, however, a study of the relative intensities of the X-ray reflexions showed that an appreciable amount of γ-alumina had been converted to boehmite. This suggested that the greater surface area of the detached film had contributed significantly to the extent of hydration.

These results show that water-sealing of boric acid anodic films is a hydration process and occurs independently of the presence of metallic aluminium.

R. M. HINDE
E. A. KELLETT
P. H. HARRIS

Research Laboratories
British Insulated Callender's Cables, Ltd.,
Wood Lane,
London, W.12. Nov. 10.

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Electrode Potentials and Compound Formation in the Palladium–Platinum–Hydrogen System

ELECTRODE potentials and electrical resistances of palladium wires alloyed with 5, 10, 20 and 25 per cent platinum have been measured while they absorbed hydrogen (dissolved under a pressure of 1 atm.) from aqueous solutions of 2 *N* sulphuric acid. Apparatus and techniques were similar to those previously employed[1]. The wires were 0·027 cm. in diameter and were prepared by directly alloying the metals. The measurements reported were made on 15-cm. lengths of wire in the cold-drawn condition, which were preactivated by discharging oxygen at their surfaces by electrolysis[2,3]. Potentials differing from zero were positive with respect to a platinum hydrogen electrode in the same solution.

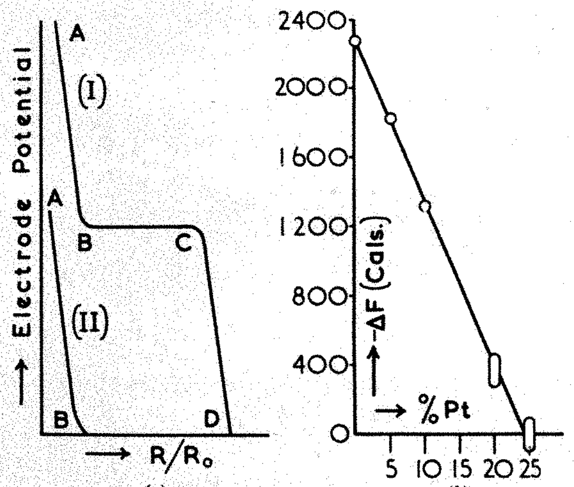
Selected experiments using the method of vacuum outgassing[1,2] indicated that the relative resistance (R/R_0) of the alloys was proportional to the hydrogen content, as has been established in detail for the palladium–hydrogen system[4]. Plots of R/R_0 against electrode potential for the alloys with 5, 10 and 20 per cent platinum revealed that they behaved[1] like palladium, showing the general relationship illustrated by I in Fig. 1*a*, although with increasing platinum content the step *BC* showed increasing departure from the horizontal with respect to the R/R_0 axis. The behaviour of the 25 per cent platinum alloy is shown by II in Fig. 1*a*. As was found for the palladium–hydrogen system, the equilibrium potential (*D* in Fig. 1*a*) is zero with respect to the platinum–hydrogen electrode.

The electrode potentials can be related to the change in free energy $\Delta \overline{F}$ for the reaction :

$$x\text{H} : y\text{Pt} : z\text{Pd} + \tfrac{1}{2}\text{H}_2 \rightleftharpoons (x+1)\text{H} : y\text{Pt} : z\text{Pd}$$

where x, y, and z represent numbers of atoms. Using the relation $\Delta F = -n\mathfrak{F}E$ and the experimental value of E, namely, 46·8 ± 0·5 mV., found for point B (Fig. 1*a*) in the palladium–hydrogen system at 30° C., ΔF for the formation of an idealized compound $\text{PdH}_{0\cdot5}$ is − 2,158 ± 24 cal./mole of hydrogen, between the limits PdH_r and $\text{PdH}_{r+0\cdot5}$, where PdH_r represents the composition at B (that is, the maximum solid solubility of hydrogen in palladium). This compares with $\Delta F = -2{,}306 \pm 12$ cal./mole of hydrogen which has recently been determined from gas-phase isothermal measurements[5]. The change in free energy associated with the formation of non-stoichiometric palladium–platinum–hydrogen compounds is also identified with the electrode potential represented by B (Fig. 1*a*) for each palladium–platinum alloy. (The definition of this point was subject to an uncertainty of ± 2 mV. in the case of the 20 and 25 per cent platinum alloys.) Fig. 1*b* shows these free energies of formation per mole of hydrogen, at 25° C., plotted against the platinum content of the alloys.

It has been suggested from previous evidence that a two-phase region analogous to that of the palladium–hydrogen system would not be formed by the absorption of hydrogen in palladium–platinum alloys with more than 5 per cent platinum. However, it is indicated by Fig. 1*b* that a two-phase region may occur in palladium–platinum alloys with less than 25 ± 2 per cent platinum.



(*a*) (*b*)

Fig. 1

Hydrogen dissolved in alloys with more than 25 ± 2 per cent platinum should be present only as a primary solid solution and appreciable solubility of hydrogen has been reported in palladium–platinum alloys containing 25–35 per cent platinum[6,7]. The gross dimensional changes of palladium foils which occur when they are repeatedly saturated with hydrogen[8] are possibly associated with the formation and collapse of the non-stoichiometric β-phase palladium hydride. Palladium–platinum alloys containing about 30 per cent platinum may therefore have advantages over pure palladium as diffusion membranes for hydrogen.

Acknowledgment is due to the Mond Nickel Co., Ltd., for providing the palladium–platinum alloys used in this investigation.

A. W. CARSON
T. B. FLANAGAN
F. A. LEWIS

Chemistry Department,
Queen's University,
Belfast.
Nov. 1.

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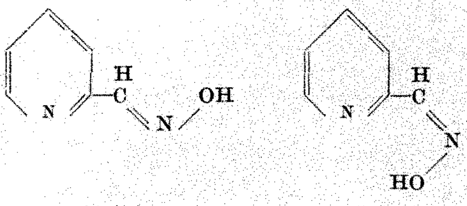
Ferrous and Ferric Complexes with Pyridine 2-Aldoxime

PYRIDINE 2-ALDOXIME forms well-defined coloured complexes with ferrous and with ferric ions in aqueous solution. The ferrous complex is violet-red in alkaline solution (with an absorption maximum at 530 mμ), reddish-orange in slightly acidic solution (with a maximum at 515 mμ), and golden-yellow below *p*H 3 (with a maximum at 475 mμ). The ferric complex is reddish-brown in alkaline, neutral and slightly acidic solution (with no absorption maxima in the visible), and yellow in more acidic solution. All the colour changes are reversible.

If this compound had the *syn* configuration (see Fig. 1), then these colour changes are most probably the result of ionization of the OH group. On the other hand, if the molecules are in the *anti* form, then the iron atom in the complex could only be bonded to nitrogen and oxygen, as can easily be verified by examination of atomic models. In the latter case the colour changes will have to be attributed to ionization on the basic unbonded nitrogen of the oxime.



(*syn*) (*anti*)

Fig. 1

Recently, Krause and Busch[1] prepared some nickel (II) complexes of this ligand. Drawing the analogy between their system and the corresponding ones with α-α′-dipyridyl and with dimethylglyoxime, they assumed that the nickel atom was bonded to two nitrogen atoms in the nickel complexes of pyridine 2-aldoxime. It would seem likely that the ferrous and ferric complexes of pyridine 2-aldoxime also involve bonding of the metal atom to two nitrogen atoms. This view is supported by the following

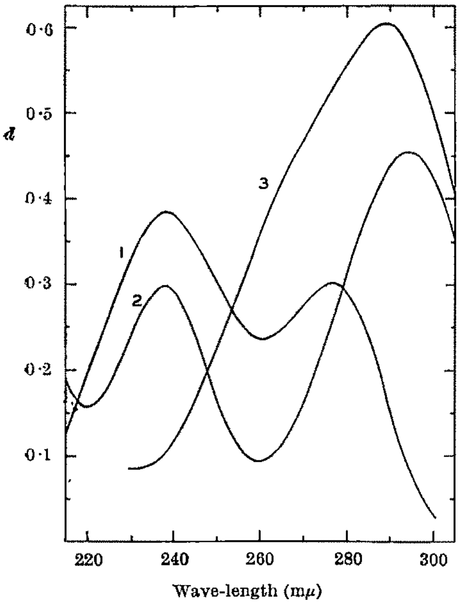


Fig. 2. Absorption spectra of $4 \cdot 0 \times 10^{-5}$ *M* pyridine 2-aldoxime showing three distinct and reversible species: (1) *PA*OH in water, absorption maxima at 238 and 277 mμ; (2) H*PA*OH at *p*H 2, maxima at 238 and 294 mμ; (3) PAO^- at *p*H 12, maximum at 289 mμ. Curves 1 and 2 have isosbestics at 218 and 279 mμ, and relate to the ionization with $pK \simeq 3$. Curves 1 and 3 have an isosbestic at 253 mμ, and relate to the ionization with $pK \simeq 10$.

evidence: (1) a number of ferrous complexes with oximes, where bonding to two nitrogen atoms has been established, have similar colours[2,3]; (2) structures of the iron(II) - pyridine 2-aldoxime complex made with Courtauld atomic models show that there is considerably less strain in the molecule when the iron is bonded to the *syn* form; (3) the infra-red spectrum of pyridine 2-aldoxime in chloroform shows a sharp band at 2·77μ which is characteristic of a free OH group; this favours the *syn* configuration rather than the *anti*, since in the latter structure the OH would most probably be involved in intramolecular hydrogen bonding with the pyridine nitrogen atom.

Pyridine 2-aldoxime shows two series of reversible spectral changes (Fig. 2) corresponding to two acid ionizations, one with $pK \simeq 3 \cdot 2$ at 25°, which is probably associated with the pyridine nitrogen, and the other with $pK \simeq 10 \cdot 2$, which is probably the ionization of the oxime OH. The normal acid *pK* value for pyridine nitrogen is 5·3, shifting to 5·8–6·0 in some pyridine-2-derivatives[4]; and for oxime OH the *pK* is[5] 12·5–13·0; in the present case conjugation could account for the increased acid strength of both groups.

Using the method of continuous variation, the composition of the ferrous complex was found to be 3 moles of ligand to 1 mole ferrous ion. This result was confirmed by measurements of changes of hydrogen ion concentrations accompanying the formation of the complex at different *p*H values, as well as by the constancy of the equilibrium constant for the formation of the complex calculated on this basis. At 25° these values are of the order of 10^{14} at *p*H 6, 10^{11} at *p*H 5, and 10^{8} at *p*H 4.

In order to account for the reversible colour changes, as well as the marked changes in the observed equilibrium constant with *p*H, we propose the following set of equilibria:

$$\begin{array}{lll}
Fe^{2+} + 3\,PAOH & \rightleftharpoons Fe(PAOH)_3{}^{2+} & (K) \\
Fe(PAOH)_3{}^{2+} & \rightleftharpoons Fe(PAO)_3H_2{}^{+} + H^+ & (K_1) \\
Fe(PAO)_3H_2{}^{+} & \rightleftharpoons Fe(PAO)_3H^0 + H^+ & (K_2) \\
Fe(PAO)_3H^0 & \rightleftharpoons Fe(PAO)_3{}^{-1} + H^+ & (K_3)
\end{array}$$

A preliminary spectrophotometric study of these equilibria indicated that $pK_3 \simeq 7 \cdot 0$ and $pK_2 \simeq 3$. It was not possible to determine pK_1 since the complex dissociates in more acidic solutions. However, the charges on these ions were substantiated by their behaviour on paper electrophoresis, and by measurements of changes of hydrogen ion concentration accompanying the formation reaction (in unbuffered solutions).

The corresponding ferric complex of pyridine 2-aldoxime is reddish-brown over a wide *p*H range. Only one reversible colour change, to orange, could be observed, corresponding to $pK \simeq 2$. This most probably corresponds to pK_3 of the ferrous complex, the other ionizations being those of strong conjugate acids. The shift in pK_3 from the ferrous to the ferric complex is of the same order of magnitude as that observed for the first ionization of hydrated ferrous and ferirc ions[6,7]. On the other hand, the shift of *pK* for the OH group in free pyridine 2-aldoxime and its ferrous complex, respectively, is unexpectedly large, considering that the types of charge are the same in both the ionization of the free ligand and the third ionization of the ferrous complex. The shift, which is clearly the result of co-ordination of the ligand to the metal atom, shows the extent to which co-ordination can influence adjacent ionizable groups. In this case, the interaction between the metal and the ionizing group is substantially increased through conjugation of the type shown in Fig. 3; in other cases, different types of interaction would be expected to produce different shifts in *pK* values.

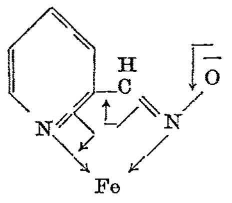


Fig. 3

These results may well be of significance in the interpretation of data obtained for all systems where there are linked effects between the metal ion and the ionizing side-groups of the ligand, such as occurs in hæmoproteins. Studies of this nature help in placing limits on the magnitudes of *pK* changes for ionizing groups which might be expected on account of the difference between their structural environment in the free ligand—where there are no linked effects—and in co-ordination complexes, where specific interaction with the metal ion can occur.

A more detailed study of the kinetics and thermodynamics of this system is being carried out. It is also hoped to extend this work to include systems incorporating other ionizable side-groups as well as other types of interaction.

We wish to thank Profs. A. Day and P. George for their co-operation. This work has been carried out as part of a programme supported by grants from the United States Public Health Service

(*RG* 4850) and the National Science Foundation (*G* 2309).

G. I. H. Hanania

Department of Chemistry,
University of Pennsylvania,
Philadelphia, U.S.A.

D. H. Irvine

Department of Chemistry,
University College,
Ibadan, Nigeria.

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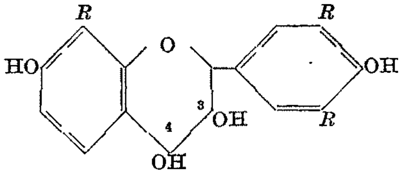
Mechanism of Formation of Anthocyanidins from Leucoanthocyani(di)ns

Based mainly on suggestions made earlier by Robinson and Robinson[1] for their hypothetical *leuco*anthocyanin (flavan-2.3.4-triol), the conversion of flavan-3.4-diols (I) into anthocyanidins by similar mechanism has been discussed by Bate-Smith[2], Bauer, Birch and Hillis[3] and by King and Clark-Lewis[4]. The reaction, induced by hydrochloric acid, was regarded as a dehydration of the 3.4-diol group on the heterocyclic ring (loss of hydroxyl at 4 and hydrogen at 3), followed by oxidation[2–4] or by disproportionation[3,4].

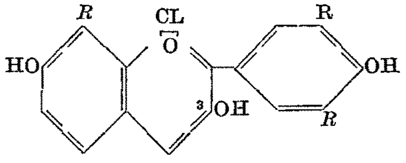
Hitherto *leuco*anthocyanins of unknown structure and also flavan-3.4-diols were conveniently treated with aqueous 2 *N* hydrochloric acid[5], with aqueous 3 *N* hydrochloric acid/propan-2-ol (1 : 5) under pressure[6] or with hydrochloric acid butan-1-ol[4,7] mixtures at 100° C. In most cases the reaction was characterized by low yields of anthocyanidins formed. Logically, if it is correctly surmised that the initial reaction constitutes a dehydration[1–4] at the diol grouping, the formation of anthocyanidins should be promoted by anhydrous conditions. This theory has now apparently found support in the observation that exclusion of moisture from the reaction mixture effects an increase in the yield of anthocyanidins formed.

For example, 7.3′.4′.5′-tetrahydroxyflavan-3.4-diol[8] is converted into anthocyanidins in approximately 37–42 per cent yield by using anyhdrous $N/30 - N/50$ hydrochloric acid in propan-2-ol in an enclosed tube under pressure. By comparison, this flavan-3.4-diol (*leuco*robinetinidin) is converted into robinetinidin only, in 3 per cent yield in 3 *N* hydrochloric acid and 20 per cent yield[8] with 3 *N* hydrochloric acid/propan-2-ol under the conditions of Pigman *et al.*[6] Under anhydrous conditions the reaction is also far more rapid, and maximum yields of anthocyanidins result in 15–20 min. compared with 40 min. under previous conditions[6]. Other flavan-3.4-diols of type I behave similarly.

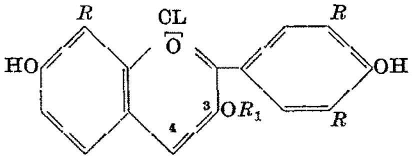
Under the new anhydrous conditions two anthocyanidins of similar coloration but with different rates of migration on paper chromatograms are generated from each flavan-3.4-diol. In all instances examined the anthocyanidin of lower R_F corresponds to that (II) generated under aqueous conditions, and the anthocyanidin of higher R_F is probably the corresponding 3-*iso*propyl ether derivative III (or possibly a 4-*iso*propyl ether of a new type of anthocyanidin). Ether formation with the 3 (or possibly the 4) position of the flavan-3.4-diol occurs prior to conversion into the corresponding anthocyanidin, and is promoted by anhydrous conditions established for the reaction. In the presence of 20 per cent moisture[6] the formation of the ether (III) is almost, but not entirely, inhibited, and mainly one anthocyanidin (II) results.



(I)



(II)



(III)

R = H or OH R_1 = *iso*Propyl

Pigman *et al.*[6] in 1953 first demonstrated the presence of *leuco*anthocyanins in some commercial tanning extracts, for example, wattle (*Acacia mollissima*), quebracho (*Schinopsis* spp.) and mangrove (*Rhizophora* spp.), and the new method represents a modification of their improved conditions. The tannins present in these extracts may be converted into anthocyanidins in 5–9 per cent, 13–21 per cent (*S. quebracho-colorado*) and 16·5 per cent (*R. mucronata*) yields respectively (cf. ref. 7). Details of a study of the reaction conditions, the reaction mechanism, and implications for the chemistry of condensed tannins will be published elsewhere.

David G. Roux
M. C. Bill

Leather Industries Research Institute,
Rhodes University,
Grahamstown,
South Africa.

Sept. 30.

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Detection of Meprobamate on Paper Chromatograms

In a recent communication, Drs. A. Fiori and M. Marigo[1] described the identification of meprobamate by adsorption chromatography on chromatoplates. Their method is both complex and laborious compared with the technique of paper chromatography, but was advocated because meprobamate appeared to be insoluble in water and because there were no available methods for detecting it on paper.

Paper chromatography can, however, be used in the identification of this substance. Meprobamate is slightly soluble in water, and we have found that it may be detected on paper chromatograms by the hypochlorite modification[2] of the chlorination method first described by H. N. Rydon and P. W. G. Smith[3]. The paper is sprayed when dry, first with 1 per cent sodium hypochlorite, then with ethanol and finally with a mixture of equal volumes of 1 per cent starch and $M/20$ potassium iodide.

This method has been used for identifying meprobamate in the urine of a patient in coma, in whom the diagnosis had previously been in doubt. A report of this case, with details of the chemical methods by which the diagnosis was established, is being published elsewhere[4]. In this context, it is of interest that the chlorination method, which has numerous applications, has recently been used to detect barbiturates on paper chromatograms[5].

H. S. Bedson*

The Medical Unit,
London Hospital, E.1.

T. H. Farmer

Department of Experimental Biochemistry,
London Hospital Medical College,
London, E.1.
Oct. 31.

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* Present address: Department of Bacteriology, The University, Liverpool 3.

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BIOCHEMISTRY and PHYSIOLOGY

Cellulose Acetate Membranes suitable for Osmotic Measurements

In a recent paper[1] it has been shown that 'Ultrafein filters allerfeinst', which the manufacturers state are composed of an unnamed cellulose ester, can be used to measure quite low number average molecular weights ($\overline{M}_n$). We have now found that membranes having similar osmotic properties can, in fact, be prepared from cellulose acetate.

The membranes are prepared by casting acetone solutions of cellulose acetate, containing *n*-amyl alcohol as precipitant[2], and allowing them to evaporate until nearly dry. The actual conditions for carrying out this operation appear to be rather critical, and so far a procedure giving absolutely reproducible membranes has not been evolved. However, by using the following method, membranes which show similar variations in osmotic properties to those found with the 'Ultrafein filters allerfeinst' can be prepared.

The following solution is made up: 5 per cent (w/w) cellulose acetate; 5 per cent (w/w) *n*-amyl alcohol; 90 per cent (w/w) acetone, and a volume containing enough cellulose acetate to give a 'membrane density' (that is, weight per unit area) of 0·005 gm./cm.^{2} is poured into a level glass dish and allowed to evaporate at room temperature in a cabinet free from draughts. As the membrane dries out, the surface first of all looks like orange peel and then goes opaque. For osmotic purposes the structure is fixed just before the membrane becomes opaque by pouring on ethanol. In a typical membrane, when the ethanol is poured on, three distinct zones appear: (1) a clear zone; (2) a white zone; (3) a white zone with dark spots. The effective part of the membrane is the white portion, since the clear areas (opaque before the addition of ethanol) have dried out too much and are usually impermeable, while the dark spots indicate pinholes which occur when the membrane has not dried out enough. The membranes are left in ethanol for at least 1 hr. to remove any residual amyl alcohol and are then conditioned to the required solvent; for example, in the case of benzene the membranes are left for periods of at least 1 hr. in (*a*) a 50 ethanol/50 benzene mixture and then (*b*) benzene.

The membranes used in the experiments described here were assembled in standard Zimm-Myerson type osmometers[1] and characterized by: (*a*) the solvent permeability, as measured by the rate of fall of solvent in the measuring capillary from a 10-cm. head; and (*b*) the solute selectivity as measured by the maximum osmotic pressures developed with a 1 per cent (w/w) solution of a 'commercial' polystyrene and/or a 0·025 per cent (w/v) solution of sucrose octaacetate (molecular weight 679).

In Table 1 results with typical and very selective membranes of both cellulose acetate and 'Ultrafein filters allerfeinst' are shown. It will be seen that the cellulose acetate membranes compare very favourably with the 'Ultrafein filters allerfeinst', having similar solute selectivities combined with slightly

Table 1. Comparison of 'Ultrafein Filters Allerfeinst' and Cellulose Acetate Membranes; Benzene Solutions at 30° C.

Membrane		Permeability	Selectivity							
			1·0 per cent (w/w) commercial P.S.				0·025 per cent (w/v) sucrose octaacetate*			
			Rising		Falling		Rising		Falling	
Type	Reference No.	Fall from 10-cm. head of benzene (cm./5 min.)	h_r (cm.)	Time (hr.)	h_f (cm.)	Time (hr.)	h_r (cm.)	Time (hr.)	h_f (cm.)	Time (hr.)
Typical membranes										
'Ultrafein filter allerfeinst'	*UFF/AF* 257/2	0·22	8·95	23	8·81	46	0·34	47	—	—
Cellulose acetate	*CA*2/58	0·81	8·61	16·5	8·65	4	—	—	—	—
Very selective membranes										
'Ultrafein filter allerfeinst'	*UFF/AF* 1257/2	0·062	—	—	—	—	5·30	48·5	5·23	30
Cellulose acetate	*CA*1/68	0·175	11·15	43	—	—	5·11	30	5·44	65

* $h_{\text{theor.}}$ = 10·86 cm.

Table 2. Determination of $\overline{M}n$ of an Ionic Polystyrene using Cellulose Acetate Membranes *CA*3/4; Benzene Solutions at 30° C.

Concentration C per cent (w/v)	Equilibrium osmotic pressures					Number average molecular weight $\overline{M}_n$
	Rising h_r (cm.)	Rising Time (hr.)	Falling h_f (cm.)	Falling Time (hr.)	h (cm.)	
0·100	7·64	40	7·54	31	7·64	3,800±200
0·080	6·15	50	6·33	112·5	6·24	
0·060	4·56	49	4·59	28	4·57	
0·040	3·39	89	3·36	44·5	3·38	
0·020	1·60	70	1·54	50	1·60	

higher solvent permeabilities. The very selective membranes can be used for determining quite low molecular weights and in Table 2 are shown the results obtained using membrane *CA*3/4 with an ionic polystyrene having $\overline{M}_n = 3,800$. Unfortunately, while it is comparatively easy to make membranes such as *CA*2/58, only a few membranes like *CA*1/68 and *CA*3/4 have so far been prepared. In these experiments benzene was used as solvent, but successful osmotic measurements have also been made in toluene and water.

The cellulose acetate used in the experiments was obtained from the British Drug Houses, Ltd.

I wish to thank Miss S. A. Monksfield and Miss H. M. Sankey for assistance with the experimental work. This work forms part of the research programme of the National Chemical Laboratory and is published by permission of the Director.

M. F. Vaughan

Department of Scientific and Industrial Research,
National Chemical Laboratory,
Teddington, Middlesex.

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Liquid/Solid Content of Fats

The consistency of margarine and other commercial fats depends to a large extent on the relative amounts of liquid and solid fats present. The usual method for determining these values is by dilatation measurements and the dilatometer is used fairly considerably for this work. There are, however, certain inherent errors in this type of measurement. It is stated that the calculation of liquid/solid content from dilatometric data is either not possible with any degree of accuracy[1] or even that it is impossible[2] with complex mixtures of glycerides. This arises from the fact that a prior knowledge of the glycerides present is required and that mathematical adjustment is needed to take account of the different melting dilatations. Such prior knowledge is not always available.

We have recently found that the use of low-resolution nuclear magnetic resonance spectroscopy provides a new means for such determinations which eliminates many of the inherent errors of the dilatation method. In effect, use is made of the inherent disparity in the nuclear magnetic line-widths observed with liquids and solids. It is known that the shape of the hydrogen resonance line is influenced by the chemical and physical state of the sample and that the width is related to the mobility of the compound containing the hydrogen and to the field homogeneity. With solids the line-width is of the order of several gauss, while with liquids the line-width is very narrow and is determined by the inhomogeneity of the applied magnetic field[3].

An example of the method adopted is illustrated by the determination of the liquid content of simple mixtures of known amounts of tristearin and triolein (tristearin does not form a solid solution in the triolein phase). A bridged-T nuclear magnetic resonance spectrometer was used[4]. The magnetic field was modulated at a sinusoidal frequency of about 40 c./s. with a magnitude of about 30 milligauss, peak to peak. The line-width was determined by the inhomogeneity of the magnetic field and was about 100 milligauss at half-height. Under these conditions the derivative curve shows no signal due to the broad band of the solid, and a measure of the peak-to-peak height of the recorded derivative curve is a direct measure of the amount of liquid present. By comparing the peak-height for any of the mixtures with that for 100 per cent liquid, the liquid content can therefore be determined. Typical results are shown in Table 1. Similar work has also been carried out with other fat mixtures.

Table 1

Known percentage of liquid glyceride	Average percentage found
75·1	74·0
50·2	51·2
25·1	25·4

The new technique has the following advantages:

(*a*) Fats or mixtures may be examined in the state in which they are received, that is, without altering the structure by melting or crystallization.

(*b*) The results are independent of the particular composition of the fat, that is, no prior knowledge of the glycerides present is required.

(*c*) The results are independent of the polymorphic form of the solid present.

A full account of this work will be reported elsewhere.

D. Chapman

Research Department,
Unilever, Ltd.,
Port Sunlight.

R. E. Richards
R. W. Yorke

Physical Chemistry Laboratory,
Oxford.

Oct. 23.

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Determination of Galactosediethylmercaptal and 3,6 Anhydrogalactosediethylmercaptal with the Anthrone and Seliwanoff Reagents

Some pure 3,6 anhydro-L-galactose was required as standard to determine the concentration of this sugar in several algal polysaccharides. Efforts to prepare it in a crystalline form were unsuccessful. Therefore the standard solution was made up from the 3,6 anhydro-L-galactosediethylmercaptal. Unfortunately the ethylmercaptan liberated on acid hydrolysis of the mercaptal interfered with colour formation in the anthrone and Seliwanoff tests. A similar interference was obtained with the diphenylamine reagent[1]. A method was developed to obtain from 3,6 anhydro-L-galactosediethylmercaptal, in quantitative yield, a solution of 3,6 anhydro-L-galactose free of ethylmercaptan. The object of this communication is to describe the method whereby sugar mercaptals can be analysed with colorimetric sugar reagents.

The galactose diethylmercaptal was prepared by Wolfrom's method[2] and 3,6 anhydro-L-galactosediethylmercaptal was obtained from the mercaptolysis of agar[3]. Anthrone reagent was dissolved in 80 per cent v/v sulphuric acid. 2 ml. of sugar were added to 10 ml. of anthrone reagent, mixed in an ice-bath and heated for 20 min. at 80° C. The conditions were optimum for the simultaneous determination of galactose and 3,6 anhydro-L-galactose in agar[4]. The conditions for the Seliwanoff test were those of Roe[5].

Solutions of galactose diethylmercaptal (159 μgm./2 ml. water) and 3,6 anhydro-L-galactosediethylmercaptal (82·7 μgm./2 ml. water) were analysed with anthrone and Seliwanoff reagents. The optical densities with the anthrone reagent of the two mercaptals were, respectively, 10 per cent and 98 per cent less than those of equimolar quantities of galactose and 3,6 anhydro-L-galactose (Table 1). With the Seliwanoff reagent the optical density of 3,6 anhydro-L-galactosediethylmercaptal was 6 per cent less than that of 3,6 anhydro-L-galactose.

Table 1. OPTICAL DENSITIES OF MERCAPTALS AND SUGAR RESIDUES

Sugar	Concentration (μgm.)	Anthrone reagent 625 mμ	Seliwanoff reagent 520 mμ
Galactose	100	0·400	0·015
Galactose from galactose diethylmercaptal*	100	0·395	—
Galactose diethylmercaptal	159	0·360	—
3,6 Anhydro-L-galactose from 3,6 anhydro-L-galactose-diethylmercaptal	50	0·410	0·425
3,6 Anhydro-L-galactose diethylmercaptal	82·7	0·010	0·400

* μgm. of sugar obtained in demercaptolysis with 10 moles mercuric chloride at 50° C. for 1 hr.

In the colorimetric tests the hydrolysis of the mercaptals in hot acids involves removal of the ethylmercaptan and formation of the colour complex with the decomposition products of the sugar residues. The results showed that the formation of colour in the anthrone reaction was inhibited by traces of ethylmercaptan. Therefore the optical density obtained with the anthrone reagent was used as an index to determine the rate and degree of demercaptolysis.

The following method was used for the demercaptolysis of the sugar mercaptals. 5 ml. of a stock solution which contained 794·5 μgm. of galactose diethylmercaptal per ml. or 413·5 μgm. of 3,6 anhydro-L-galactosediethylmercaptal per ml., a microspatula scoop of cadmium carbonate and 10 moles of mercuric chloride/mole of sugar were added to a 50-ml. volumetric flask. The mixture was heated for ½ hr. at 50° C., diluted to volume and then passed through a sintered glass filter to remove the mercury mercaptide.

The conditions reported in the literature for the demercaptolysis of 3,6 anhydro-L-galactosediethylmercaptal require 1·75 moles of mercuric chloride/mole of sugar, heated for 5 hr. at 50° C., yield not reported[6], and 2 moles of mercuric chloride/mole of sugar held for 3 hr. at room temperature with a 56 per cent yield[3]. The results in Tables 2 and 3 showed that at least 4 moles of mercuric chloride were required to obtain complete removal of the ethyl mercaptan. When galactose diethylmercaptal and 3,6 anhydro-L-galactosediethylmercaptal were treated with 10 moles mercuric chloride for ½ hr. at 50° C. a quantitative yield of galactose and maximum colour formation with 3,6 anhydro-L-galactose was obtained. A large excess of mercuric chloride, 100 moles, had no effect on the optical density of solutions of galactose, fructose and 3,6 anhydro-L-galactose with the anthrone and Seliwanoff reagents.

Table 2. EFFECT OF MERCURIC CHLORIDE ON THE DEMERCAPTOLYSIS OF 3,6 ANHYDRO-L-GALACTOSEDIETHYLMERCAPTAL*

Mercuric chloride (moles)	2	3	4	10	100
D. anthrone reagent	0·362	0·390	0·405	0·408	0·405

* Reaction for 1 hr. at 50° C. 50 μgm. of 3,6 anhydro-L-galactose.

Table 3. RATE OF DEMERCAPTOLYSIS OF 3,6 ANHYDRO-L-GALACTOSE-DIETHYLMERCAPTAL*

Time in hr. at 50° C.	½	1	12	30 min. at 25° C.
D. anthrone reagent	0·405	0·408	0·410	0·350

* Reaction 10 moles of mercuric chloride/mole of sugar 50 μgm. of 3,6 anhydro-L-galactose.

In summary, a method has been developed to use colorimetric sugar reagents for the analysis of mercaptals. The sensitivity of the anthrone reaction to ethylmercaptan provided a simple index to determine conditions for complete demercaptolysis of sugar mercaptals.

I wish to acknowledge the assistance of the late Dr. A. N. O'Neill in the preparation of the mercaptals.

W. YAPHE

Atlantic Regional Laboratory,
National Research Council,
Halifax, Nova Scotia.
Oct. 10.

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Oxidative Phosphorylation in the Chick Embryo

SYNTHESIS of high-energy phosphate bonds was measured by the estimation of phosphorus : oxygen ratios. The materials used were 7–9 day old chick embryos of a hybrid White Leghorn ♀ × New Hampshire Red ♂. Except for the step *iso*citrate → succinate, the estimations were done on the mitochondrial fraction, prepared according to the method of Hogeboom and Schneider[1]. Oxygen consumption was measured by the Warburg technique, using 0·1 *M* phosphate buffer at *p*H 7·4 with the addition of adequate co-factors and substrates[2]. Phosphorus estimations were carried out according to the method of Lowry and Lopez[3].

Table 1 summarizes our results. Steps, pyruvate → acetyl coenzyme A, and malate → oxalacetate show 3·0 as probable ratios in the cell, whereas phosphorus : oxygen ratios of 2·0 are characteristic of the remaining steps. Estimations of the step *iso*citrate → succinate on mitochondria showed a very low ratio, in the majority of cases less than 1·0; the same occurred when citrate was used as substrate. On the other

Table 1. Phosphorus : Oxygen Ratios of Different Steps within the Krebs Cycle

(In parenthesis : number of experiments)

•	Phosphorus : Oxygen ratio	
	Observed	Probable in intact cell
Pyruvate → Acetyl coenzyme A	2·1 (15)	3·0
*iso*Citrate → Succinate	2·0 (16)*	3·0
Alpha-ketoglutarate → Succinate	1·9 (19)	2·0
Succinate → Fumarate	1·8 (16)	2·0
Malate → Oxalacetate	2·6 (13)	3·0

* Obtained on homogenates

hand, when homogenates were used, the phosphorus : oxygen ratio increased to 2·0 with *iso*citrate (14 experiments) and 2·2 with citrate (10 experiments), which point to a probable phosphorus : oxygen ratio of 3·0 inside the cell. In this respect the embryonic mitochondria behave differently from those of the rat liver ; Copenhaver and Lardy[4] showed an estimated phosphorus : oxygen ratio 2·6 for citrate. Our estimations on the rat liver mitochondria gave an average of 2·1 with citrate as substrate.

Full details of this work will be published elsewhere. It was aided by U.S. Public Health Service Grant *C*–2296 (*C*7).

Wiktor W. Nowinski
William C. Mahaffey

Tissue Metabolism Research Laboratory,
University of Texas Medical Branch,
Galveston, Texas.
Oct. 27.

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Synthesis of Amylose by Potato *D*-Enzyme

The synthesis of the chain-forming α-1 : 4-bonds of potato starch (amylose + amylopectin) has for long been ascribed to phosphorylase acting on glucose-1-phosphate and a preformed starch-like primer[1]. We now report the synthesis of amylose-like material by another enzyme system from potato. This synthesis makes use of *D*-enzyme, discovered in 1953 by Peat and co-workers[2]. *D*-enzyme catalyses the reversible disproportionation of maltodextrins, the glucose oligosaccharides containing the α-1 : 4-linkage. For example, maltotriose is acted on to give, as the first products of reaction, glucose and maltopentaose, and at equilibrium glucose and a whole series of maltodextrins are present. However, with maltotriose as the initial substrate, none of the synthetic oligosaccharides is of sufficient length to form a coloured complex with iodine. The minimum length for colour formation is at least 12 glucose units[3]. Incubation of *D*-enzyme with a maltodextrin and glucose lowers the average length of the polymer because of transfer of some of its glucose residues to the added glucose. It was realized that a reversal of this procedure, the removal of glucose, should increase the length of the polymers and might ultimately result in the synthesis from a small maltodextrin molecule of an iodine-staining, amylose-like polysaccharide. If, in addition to *D*-enzyme, the potato is equipped with such a glucose-removing enzyme system, then it is presumably capable of synthesizing amylose by a route other than that provided by phosphorylase. A suitable glucose-removing system is hexokinase and adenosine triphosphate, and hexokinase is known to be in the potato[4]. This will convert glucose into glucose-6-phosphate, and *D*-enzyme does not transfer chain segments from maltodextrins to the sugar phosphate as it does to glucose[5]. The system (maltodextrin + *D*-enzyme + hexokinase + adenosine triphosphate) should therefore bring about amylose synthesis. This has been achieved.

We have preferred to use yeast hexokinase in the present experiments because it can be obtained in a better state of purity than the potato enzyme. In the first instance *D*-enzyme was incubated with a mixture of maltodextrins (malto-pentaose, -hexaose and -heptaose) from which some of the products of *D*-enzyme action alone are long enough to stain with iodine[2]. The same system with added hexokinase and adenosine triphosphate produced iodine-staining material at more than twice the rate. The experiment was repeated with maltotetraose, which with *D*-enzyme alone does not give iodine-staining products. Fig. 1 depicts the course of reaction of *D*-enzyme + maltotetraose in the presence and absence of the glucose-phosphorylating system. When glucose was continuously removed as the 6-phosphate there was an abundant production of iodine-staining polysaccharide, and correspondingly adenosine triphosphate disappeared.

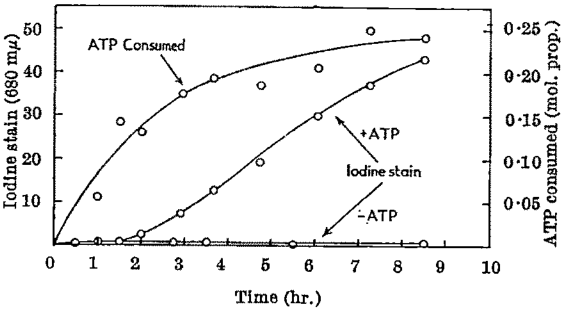

Fig. 1. Synthesis of amylase from maltotetraose. *D*-enzyme was incubated at 25° C. with hexokinase and maltotetraose in the presence and absence of adenosine triphosphate (ATP). The *p*H was maintained at 7·2 by the frequent addition of sodium hydroxide

The suggestion has been made[6] that the potato may use both phosphorylase and *D*-enzyme to synthesize amylose, the product from phosphorylase remaining as amylose and from *D*-enzyme being converted into amylopectin by *Q*-enzyme. Experiments are now in progress to demonstrate the working of such a system *in vitro*.

This work was made possible by grants from the Agricultural Research Council, to which we express our thanks. We also thank Dr. K. Rees for a gift of hexokinase.

Gwen J. Walker
W. J. Whelan

Lister Institute of Preventive Medicine,
London, S.W.1.
Oct. 29.

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Cotinine: an Oxidation Product of Nicotine formed by Rabbit Liver

A MAJOR advance in the elucidation of nicotine metabolism was the demonstration by McKennis *et al.*[1] that dogs receiving nicotine excreted small amounts of γ-(3-pyridyl)-γ-methylaminobutyric acid and its lactam, cotinine. These workers favoured the view that cotinine was formed in urine by spontaneous lactamization of the acid. However, they also suggested that cotinine might be an intermediate in nicotine metabolism which was hydrolysed to the acid *in vivo*.

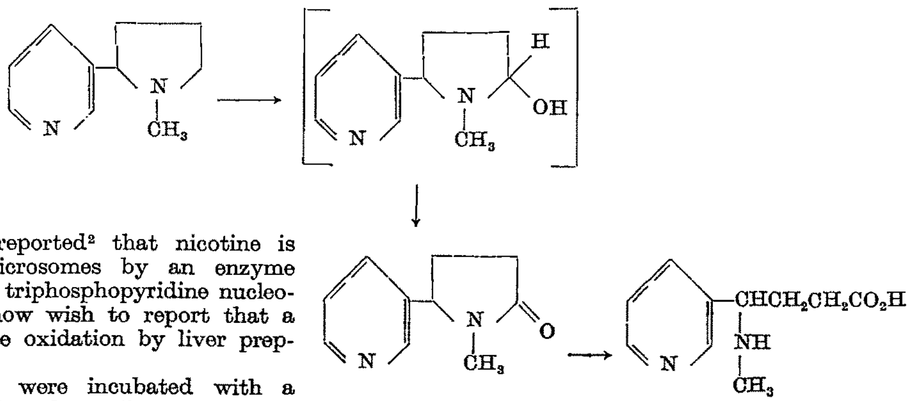
We have previously reported[2] that nicotine is metabolized in liver microsomes by an enzyme system requiring reduced triphosphopyridine nucleotide and oxygen. We now wish to report that a major product of nicotine oxidation by liver preparations is cotinine.

3 μmoles of nicotine were incubated with a supernatant fraction of rabbit liver (prepared at 9,000*g*), supplemented with triphosphopyridine nucleotide (0·5 μmole), glucose-6-phosphate (25 μmoles) and nicotinamide (0·1 μmole), for 90 min. at 37° C. under oxygen. Unchanged nicotine was extracted into heptane and assayed spectrophotometrically (259 mμ in 0·1 *N* hydrochloric acid). Cotinine remaining in the aqueous phase was then extracted into chloroform. After washing with 0·1 *M* citrate buffer, *p*H 5·0, to remove an unidentified metabolite, the chloroform phase was extracted with 0·1 *N* hydrochloric acid. Material in the acid phase, accounting for about half the metabolized nicotine, was tentatively identified as cotinine by ultra-violet absorption ($\lambda_{max.}$ 262 mμ), comparative distribution ratios[3] and paper chromatography with three solvent systems.

The metabolite was isolated as follows: nicotine (1,200 μmoles) was incubated with 1,200 ml. of liver supernatant fraction and other components in proportion. Cotinine was extracted into chloroform as described above and the organic phase washed with citrate buffer, *p*H 5·0. After evaporation of the chloroform at room temperature under nitrogen, the residue was subjected to an eight transfer countercurrent distribution between equal volumes of chloroform and 0·6 *M* citrate buffer, *p*H 3·5. Contents of tubes 3–6 containing material of similar partition ratios were pooled, alkalinized and the total basic material extracted into the chloroform phase. The chloroform was evaporated and the residue taken up in ether. After drying the ether phase with sodium sulphate, addition of 60 per cent perchloric acid in ethanol (1 : 1) gave the perchlorate derivative, m.p. 218–219°. The melting point was not depressed on admixture with authentic cotinine perchlorate[4], m.p. 218–219°. Analysis—calculated for $C_{10}H_{13}N_2O_5$: C, 43·41 ; H, 4·74 ; found : C, 43·62 ; H, 5·01. The infra-red spectrum (in potassium bromide pellet) was identical with that of authentic cotinine perchlorate.

When 15 mgm./kgm. of nicotine were administered intramuscularly to rabbits, small amounts of cotinine equivalent to about 10 per cent of the dose were excreted in the urine. Similarly, less than 10 per cent of cotinine administered to rabbits (15 mgm./kgm.) intravenously was found in the urine. Since only small amounts of cotinine are excreted after administering nicotine or cotinine, it is possible that the latter compound is a major metabolite of nicotine *in vivo*.

It seems possible that the first step in the oxidation of nicotine is hydroxylation, followed by oxidation to cotinine and hydrolysis as follows :



HOWARD B. HUCKER
JAMES R. GILLETTE
BERNARD B. BRODIE

Laboratory of Chemical Pharmacology,
National Heart Institute,
National Institutes of Health.
Public Health Service,
U.S. Department of Health,
Education and Welfare,
Bethesda, Maryland.
Oct. 23.

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Composition of Lipids isolated from the Aorta, Coronary Arteries and Circulus Willisii of Atherosclerotic Individuals

INVESTIGATIONS of lipid deposits connected with atherosclerosis have usually been concerned with the lipids from the plaques formed in the intima of the aorta[1]. Although the condition of the aorta is a guide to the progress of the disease, dysfunction due to atherosclerosis is most liable to occur in the smaller arteries, especially coronary and cerebral arteries. It has generally been assumed that lipid deposition in these arteries occurs in a similar way to that in the aorta. If this is so, the composition of the lipids deposited should be approximately the same. Lipids extracted from different atheromatous arteries have been examined in order to test this assumption.

The amount of lipid extractable from coronary or brain arteries is extremely small (as indeed it is for healthy aortas), but methods have recently been developed in this laboratory for the separation of as little as 70 mgm. of tissue lipids into phospholipids, sterol esters, triglycerides, free fatty acids and free sterols. The first three groups can then be saponified and the resultant fatty acid mixtures, as well as the

Table 1. COMPOSITION OF LIPIDS FROM INDIVIDUAL ARTERIES

	Aorta (case *A*)	Circulus Willisii (case *A*)	Coronary arteries (case *A*)	Coronary arteries (case *B*)	Coronary arteries (case *C*)
Yield of lipids*	15·9	10·7	23·7	21·4	15·0
Composition (per cent)					
Phospholipids	26·8	29·5	16·7	16·7	19·2
Free fatty acids	0·9	3·6	1·9	2·8	3·4
Free cholesterol	22·6	7·6	12·2	11·2	21·6
Cholesterol esters	36·4	46·9	21·4	25·9	28·1
Triglycerides	13·9	12·4	49·0	58·6	27·6

* As a percentage of the weight of the freeze-dried tissue.

free fatty acids, methylated and analysed by vapour-phase chromatography.

The material for the investigation (case *A*) of which the results are shown in Table 1 came from a man eighty-eight years of age; the aorta showed an advanced stage of atherosclerosis, and the coronary and brain arteries were atheromatous.

The adventitia and outer part of the media were removed from the aorta, the coronary arteries and the circulus Willisii. The remaining material was cut into small pieces, and the three preparations were freeze-dried before being extracted with methanol–chloroform (1 : 2) at room temperature.

After purification of the lipids by passage of the concentrated methanol–chloroform solution through a column of powdered cellulose[2], the phospholipids were separated from the other lipids by dialysing the latter through a rubber membrane[3], the free fatty acids removed by alkaline extraction and the remaining three groups separated by silicic acid chromatography (essentially according to Borgström[4]). The phospholipids were saponified, first with anhydrous methanolic hydrochloric acid, then with ethanolic potassium hydroxide; the triglycerides and sterol esters were saponified with ethanolic potassium hydroxide alone. The fatty acid fractions and the free fatty acids were converted to their methyl esters and are to be examined by gas chromatography.

The composition of the lipids from the different arteries is shown in Table 1. The amounts of different lipid sub-groups are given as percentages of the total lipid; those for free cholesterol, cholesterol esters and triglycerides were determined colorimetrically. The most striking result is the high percentage of triglycerides in the coronary arteries, compared with the aorta. That this was not an isolated phenomenon characteristic only of case *A* is shown by the last two columns of Table 1, where two further analyses of atherosclerotic coronary arteries (from men of 61 and 66 years, respectively) reveal a high triglyceride content. The triglyceride level of the third example (case *C*) was not as high as the other two, but was much higher than we have ever found in lipids from aortas (cf. Table 2).

Table 2. COMPARISON OF LIPID COMPOSITION OF DIFFERENT ARTERIES

	Aorta stage 0* (2 cases)	Aorta stage I* (5 cases)	Aorta stage II* (6 cases)	Aorta stage III* (5 cases)	Coronaries (3 cases)	Circulus Willisii (1 case)
Yield of lipids†	3·0	4·2	8·5	13·1	20·0	10·7
Composition (per cent):						
Phospholipids	65·8	52·5	33·3	33·6	17·5	29·5
Free fatty acids	5·2	5·8	3·4	1·4	2·7	3·6
Free cholesterol	7·7	11·8	19·1	19·8	15·0	7·6
Cholesterol esters	4·7	14·0	35·1	40·2	25·1	46·9
Triglycerides	15·0	15·4	12·0	8·6	45·1	12·4

* The aortas are classified (ref. 5) according to the appearance of the intima. Stage 0, aorta apparently free from disease; stage I, fatty streaks or spots, distinct plaques of not more than 2 mm. in diameter; stage II, plaques more than 2 mm. in diameter; stage III, complicated lesions (ulcera).

† As a percentage of the weight of freeze-dried tissue.

In contrast with the coronary arteries, the circular Willisii had a triglyceride content falling within the range observed for aortas. Both the total amount of lipids extractable from the tissue and the percentage of triglycerides in the lipids were approximately equal to those from a stage II aorta. The unusual feature in this artery was the comparatively high content of cholesterol esters, coupled with the extremely low level of free cholesterol.

No explanation of the differences is offered at present; but these preliminary findings are reported as an indication that theories concerning atherosclerosis based on observations of the aorta may have to take into account extra factors when they are applied to other arteries.

C. J. F. BÖTTCHER
F. P. WOODFORD
C. CH. TER HAAR ROMENY
E. BOELSMA
C. M. VAN GENT

Department of Physical Chemistry,
University of Leyden,
Netherlands.
Nov. 4.

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Determination of Transaminase Activity in Dogs' Serum and Lymph after Hepatic Damage due to Acute Biliary Obstruction

IT is known that glutamic-oxaloacetic acid transaminase (GOT) and glutamic-pyruvic acid transaminase (GPT) are increased in sera of patients suffering from certain liver diseases[1]; but there are scarcely any data available about the pathways of these enzymes. We have therefore studied the changes of the concentration of transaminase of hepatic origin at various points of the blood and lymphatic circulation after damage to the liver caused experimentally by biliary obstruction.

The experiments were carried out on dogs under anæsthesia with chloralose (0·1 gm. per kgm. body-weight). We collected simultaneously samples of sera from the femoral artery and hepatic veins on one hand and thoracic duct and hepatic lymph on the other. The concentration of transaminase was determined by Umbreit's method[2]. Damage to the liver was produced by ligating the common bile duct and injecting 100–150 ml. of 5 per cent sodium chloride solution. The concentrations of

Table 1. Normal Values of the Activities of Glutamic-oxaloacetic and Glutamic-pyruvic Acid Transaminases in Dogs

	Art. fem. ser.		V. hep. ser.		D. thor. lymph		Hepatic lymph	
	GOT	GPT	GOT	GPT	GOT	GPT	GOT	GPT
Mean	70	53	78	80	67	52	121	70
Extreme values	23–134	11–89	20–124	20–195	7–126	8–119	80–136	38–125
Number of cases	19	18	18	15	20	19	5	4

glutamic-oxaloacetic acid transaminase and of glutamic-pyruvic acid transaminase were determined 15 min. before and 15 min. after the injection.

Table 1 summarizes the values found in normal controls, and Fig. 1 illustrates the values found after hepatic damage.

Compared with the values of the controls, the concentrations found after hepatic damage are significantly greater in all our experiments.

So far as we know, no data on transaminase activity in the hepatic veins or in the lymph of the various lymphatic ducts have been published. According to our results, the activities of both glutamic-oxaloacetic and glutamic-pyruvic acid transaminase are considerably increased in every fraction of the blood and lymph after hepatic damage; the actual rise is to some extent variable. (In the experiment represented in Fig. 1 the greatest change occurred in the serum from the hepatic vein.)

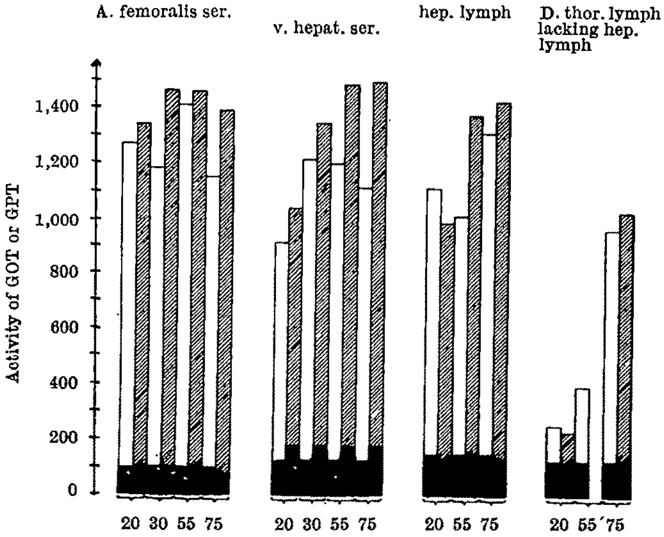

Fig. 1. Activity of glutamic oxaloacetic acid transaminase (white); and of glutamic pyruvic acid transaminase (hatched); mean of control periods (black)

Histological examination of the liver tissue showed intense hyperæmia, œdema and damage to the liver cells (vacuoles, hyalin degeneration).

P. Braun
First Department of Medicine,
University Medical School, Budapest.

M. Papp
Institute for Experimental Medical Research,
Hungarian Academy of Sciences, Budapest.

I. Horváth
Research Institute of the
Pharmaceutical Industry, Budapest.

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Effect of Insulin on Sulphydryl Groups in Muscle

It has been shown that the free —SH content of nerve tissue increases under the influence of stimulation. This suggested the possibility that the number of titratable —SH groups may be directly or indirectly related to the ratio of potassium to sodium ions in the cell and consequently to its surface potential[1,2].

Flückiger and Verzár[3], Zierler[4] and Creese, D'Silva and Northover[5] have observed that addition of insulin *in vitro* to rat-muscle preparations causes gain in potassium ions and loss of sodium ions by the cell and an increase of its resting potential. It seemed, therefore, interesting to investigate whether these changes would be accompanied by a corresponding fall in titratable —SH groups.

Diaphragms were removed from male *CF* Wistar rats (100–145 gm.). Each hemidiaphragm was washed, and suspended in 150 ml. of a glucose–saline medium buffered to *p*H 7·4 and containing 6·15 μmoles potassium ion/ml. To one of the hemidiaphragms was added insulin ('Iletin', Lilly) at a concentration of 0·1 unit/ml.; the other served as a control. A mixture of 95 per cent oxygen and 5 per cent carbon dioxide was bubbling through both preparations for 2 hr. at room temperature.

Content of potassium ions was determined in eight pairs of hemidiaphragms after 2 hr. incubation. The muscle was blotted and submitted to the wet-ashing procedure described by Ballantine and Burford[6]; content of potassium ions was measured by means of a flame photometer using an internal standard. The mean potassium ion content of the insulin-treated hemidiaphragm was 130·4 (±33·5 *S.D.*) μmoles/gm. of wet weight; the control muscles contained 82·3 (±32·8) μmoles/gm. The increase in potassium ion content, 48·1 μmoles, is 58·5 per cent of the controls.

Thirty pairs of hemidiaphragms were used for the determination of —SH groups. The tissue was frozen with dry-ice, ground in a Potter–Elvehjem homogenizer and extracted with the suspension medium. After centrifugation at 4,000 r.p.m. for 20 min., —SH groups were determined in the supernatant by means of the amperometric titration method of Benesch, Lardy and Benesch[7]. In 26 experiments the —SH content of the insulin-treated hemidiaphragm decreased by an average of 22·1 per cent. The control muscle contained 5·32 (±1·08 *S.D.*) μmoles/gm. wet weight; under the influence of insulin the —SH groups fell to 4·14 (±0·84) μmoles. The difference is significant at the level of $P = 0{\cdot}05$–$0{\cdot}02$. In four experiments —SH groups increased by an average of 1·22 μmoles/gm.: it could not be ascertained whether these results were due to a technical failure or to some particular condition of the animals.

In some experiments, the extract was dialysed in a shaking dialyser against 25 vol. of the extraction medium. As in brain tissue[2], the major proportion (80 per cent) of the —SH groups in muscle was bound to non-dialysable molecules, presumably to proteins. The decrease caused by insulin affected about equally the dialysable and non-dialysable sulphydryl fractions.

The fact that insulin causes hyperpolarization of the cell surface, increase of the ratio of potassium to sodium ions and decrease of —SH groups can be interpreted in various ways. In terms of the membrane theory, it could be assumed that insulin, by its action on metabolic processes, increases the efficiency of the ionic 'pumps' or that it acts directly on the membrane and alters its permeability properties. The latter action is assumed to operate in facilitating the entry of glucose into the cell[8]. There is also some evidence that glycogen fixes potassium ions[9] so that increased glycogen synthesis may result in higher intracellular potassium.

In view of certain observations on protein configuration in resting and stimulated cells, insulin can be assumed to act primarily by modifying the structure of certain protein molecules. Stimulation and subsequent depolarization, with lowered ratio of potassium to sodium ions, are accompanied by an 'unmasking' of titratable —SH groups and other ionized side-groups, suggesting a general 'loosening' of the structure of protein molecules[1,2,10]. In the opposite direction, hyperpolarization, with raised intracellular ratio of potassium to sodium ions could be characterized by a decrease in ionized side-groups and tendency to a more rigid protein configuration. Further investigations are being conducted to determine whether modifications of protein structure represent a determining factor in the mechanism of cellular rest and excitation.

G. UNGAR
S. KADIS

Department of Pharmacology,
U.S. Vitamin Corporation,
New York.

Oct. 28.

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Reduction of Neotetrazolium Chloride by Vitamin K_3

MENADIONE (vitamin K_3, 2-methyl-1.4-naphthaquinone) has become increasingly associated with pathways of electron transfer. It has been implicated in the nitrate reductase sequence; in the processes of photosynthetic phosphorylation; in a non-phosphorylative oxidative pathway; in menadione reductase and in the general respiratory chain and associated processes of oxidative phosphorylation (cf. ref. 1). Menadione has recently been associated with an enzyme sequence connecting the oxidation of succinate with the reduction of neotetrazolium chloride[1]. The vitamin K_3 involved in such reactions can be followed by spectrophotometric rate measurements[2].

This communication shows that it is also possible to demonstrate that vitamin K_3 is involved in redox reactions by adding neotetrazolium chloride; reduced menadione reacts directly and non-enzymically with neotetrazolium chloride at *p*H 7·4 and 37° C., yielding the intensely coloured insoluble formazan. As stated by Shelton and Rice[3], the absorption maximum of the formazan varies with the method of reduction: enzymic reduction yields a product with a maximum absorption at 510 mμ; chemical reduction (for example, by reduced menadione or dithionite) yields a product with an absorption maximum at 540 mμ.

In the following experiments the reaction mixture used contained 1 ml. of a phosphate – versene mixture (1·0 ml. phosphate buffer, *p*H 7·4, 0·1 molar : 0·05 ml. sodium versenate, *p*H 7·4, 0·1 molar) and 0·15 ml. of 1 per cent neotetrazolium chloride. Other additions mentioned in Table 1 were made in a volume of 0·1 ml. Incubation was at 37° C. and the formazan was extracted with 4 ml. of ethyl acetate; the extinction was obtained using a Hilger 'Uvispek' spectrophotometer. Vitamin K_3 was added as a suspension in phosphate buffer, bovine plasma albumin and ethanol.

Table 1. EXTINCTION READ AT 540 Mμ IN A 'UVISPEK' SPECTROPHOTOMETER

Path-length 1 cm., incubation time 30 min. except for reduced menadione (5 min.), and cysteine + vitamin K_3 (15 min.); reagents and volumes described in the text. All values refer to the addition of 1 μmole of reagent

Addition	Extinction	Addition	Extinction
Menadione	0·007	Ascorbic acid + vitamin K_3	0·225
Reduced menadione	0·237	Glutathione + vitamin K_3	0·003
Ascorbic acid	0·066	Cysteine + vitamin K_3	0·960
Glutathione	0·002	Reduced diphosphopyridine nucleotide + vitamin K_3	0·036
Cysteine	0·009	Vitamin K_1 + ascorbic acid	0·123
2,3 Dimercapto-1-propanol	1·490	Vitamin E + ascorbic acid	0·091
Hydroquinone	0·000		
Reduced diphosphopyridine nucleotide	0·000		
Vitamin K_1	0·015		
Vitamin E	0·006		

Reduced menadione was prepared as described by Fieser[4]; a grey powder was obtained which had absorption maxima at 241 and 330 mμ as mentioned by Colpa-Boonstra and Slater[2]. Direct reduction of neotetrazolium chloride by the following reagents was also tried: reduced diphosphopyridine nucleotide (Boerhinger, 90 per cent pure); glutathione (Distillers Co., Ltd.): ascorbic acid (Roche); cysteine; 2,3 dimercapto-1-propanol (BAL, Boots Pure Drug Co., Ltd.); hydroquinone; vitamin E (L. Light and Co.); vitamin K_1 (Roche).

Other than reduced menadione, only 2,3 dimercapto-1-propanol reacted directly with neotetrazolium chloride to any substantial degree; slight production of formazan was observed with vitamin C (Table 1). Several of the reagents which did not reduce neotetrazolium chloride directly, were found to reduce menadione, which then led to the formation of formazan. For example, cysteine reduced menadione with a consequent formation of formazan on incubation, in spite of the fact that cysteine (and other similar compounds, for example, glutathione) combines readily with menadione under the conditions used to yield 3-substituted naphthaquinones. Under the conditions used (in *p*H 7·4 phosphate buffer : versene) the photochemical reduction of neotetrazolium chloride catalysed by cysteine with either riboflavin or riboflavin phosphate[5] was negligible.

The reduction of vitamin K_3 by vitamin C appears to occur to a considerable extent, indicating that the following reaction is displaced to the right in the presence of neotetrazolium chloride :

$$\text{ascorbate} + \text{menadione} \rightarrow \text{dehydroascorbate} + \text{reduced menadione}$$

This reaction between vitamin C and menadione is stimulated by tissue suspensions[1], but whether this stimulation is enzymic in character must await further investigation. The stimulatory power of homogenates is relatively insensitive to boiling. The stimulatory power of both rat liver and rat mammary gland homogenates is largely concentrated in the soluble fraction after removing the mitochondria and microsomes by differential centrifugation in 0·25 molar sucrose.

Reduced diphosphopyridine nucleotide reacted only slightly, if at all, with menadione to yield reduced menadione; reduced diphosphopyridine nucleotide had no direct effect on neotetrazolium chloride, as has been reported by Zöllner and Rothemund[6]. Typical results are shown in Table 1.

It seems possible, therefore, that in certain cases the fact that vitamin K_3 is involved in redox reactions can be demonstrated by the ready interaction of reduced menadione with neotetrazolium chloride.

I am grateful to Dr. A. L. Greenbaum and D. N. Planterose for helpful comments and suggestions; this work was carried out during the tenure of a Beit Memorial Fellowship.

T. F. SLATER*

Department of Biochemistry,
University College,
Gower Street,
London, W.C.1.

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* Beit Memorial Fellow.

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Effect of β-Hydroxybutyrate Injections on the Pancreatic Activity of Guinea Pigs

β-HYDROXYBUTYRATE has been found to cause hyperglycæmia, glycosuria and lowered glucose tolerance in guinea pigs and rabbits when injected in gradually increasing doses for some time[1,2]. On injection in rabbits, this compound produces an initial state of hypoglycæmia followed in the long run by permanent hyperglycæmia. That this may be due to an initial state of hyper-insulinism, followed by hypo-insulinism due to an overwork atrophy of the *B*-cells, caused by continued stimulation has been suggested[3-6].

Since β-hydroxybutyrate is an important intermediary metabolite, its effect on the normal pancreas is evidently very interesting, and the present series of investigations have therefore been started to elucidate its mechanism of action. The present report indicates the effect produced by continued injections of β-hydroxybutyrate (sodium salt) on the amylolytic and insulin activity of the pancreatic tissue of guinea pigs.

The preliminary experiments reported here were carried out on two groups of guinea pigs. One group was kept as control, and the animals of the other group were given injections of sodium β-hydroxybutyrate (L. Light and Co., Ltd.). The initial dose was 50 mgm. per animal, and this was gradually increased to 100 mgm. per animal. At regular intervals the pancreas was removed from two animals of each group and a portion of pancreatic tissue assayed for amylase activity by Willstätter's method[7]. Another portion of the tissue was extracted for insulin[8] and the extracted insulin assayed on rabbits by the method of Burn[9]. The results are given in Table 1.

Table 1. AVERAGE VALUES OF PANCREATIC AMYLASE AND INSULIN OF GUINEA PIGS SUBJECTED TO INJECTIONS OF β-HYDROXYBUTYRATE (SODIUM SALT)

No.	Days of injections	Amylase activity mgm. of maltose/gm. of dry pancreas	Insulin potency (percentage reduction/gm. pancreas)
1	0 (control)	654·1	14·72
2	12	596·7	86·10
3	25	457·2	—
4	36	100·8	30·6

Table 1 reveals that the pancreatic amylase activity decreases with gradual increase in the dosage of β-hydroxybutyrate injections, whereas the insulin potency shows an initial increase and is then followed by a decrease. The decrease in pancreatic amylolytic activity may be due to a possible lowering of the rate in the proteosynthetic activity of the acinar cells as a result of a possible pharmacological response produced by β-hydroxybutyrate, or it might be due to a physiological response of the organ to maintain the overall enzyme–hormone balance or both. The changes in insulin potency as observed are in conformity with the order of earlier observations (*loc. cit.*), namely, initial stimulation of *B*-cells followed by a possible overwork atrophy as a response to β-hydroxybutyrate injections.

H. D. BRAHMACHARI
MAHENDRA KUMAR

Biochemistry Laboratories,
Birla College, Pilani,
India.

Oct. 23.

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Leucine Aminopeptidase Activity in Mast Cells

DURING investigations of the behaviour of leucine aminopeptidase activity of blood-serum in patients with dermatoses and tumours[1-3], in a case of diffuse skin mastocytosis of a new-born, we detected heightened activity of leucine aminopeptidase. After mechanical friction of the affected skin, greater activity of leucine aminopeptidase occurred. From this we supposed a release of leucine aminopeptidase from the mast cell infiltrates of the skin. As is well known, in urticaria pigmentosa mechanical irritation of the skin lesions give rise to a degranulation of mast cells[4,5] with liberation of histamine and serotonin. Indeed, there is no doubt that mast cells contain the enzyme leucine aminopeptidase. Using Burstone and Folk's histochemical method[6], we were able to demonstrate a strong positive cytoplasmic

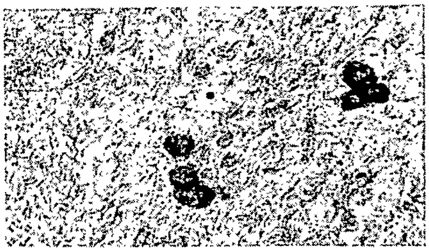

Fig. 1. Positive leucine aminopeptidase reaction in mast cells of rat mesentery

leucine aminopeptidase reaction in the mast cell infiltrates of the cutis in the above-mentioned case. Also in the mesentery of rats, mast cells likewise show a weak positive but distinct cytoplasmic leucine aminopeptidase reaction (Fig. 1), while other connective tissue cells are free of histochemically demonstrable activity of leucine aminopeptidase. To answer the question, whether with degranulation of mast cells there is a release of leucine aminopeptidase in the surrounding tissue, some experiments on rats were performed. Following Fawcett's method[7] for the release of histamine by mast cells, eight black rats (150–200 gm.) were killed and, after being bled, the abdomen was opened, the mesentery detached in its entirety at the root and separated from the intestine. After incubation in 2 ml. aqua bidest. or Tyrode's solution for 20 min. at 20° C. in 0·5 c.c. of the filtrate, the activity of leucine aminopeptidase was determined by a modified method of Green *et al.*[1]. Histological controls showed no greater morphological alterations of the mast cells by treatment with Tyrode's solution; however, after treatment by aqua bidest., the well-known osmotic rupture of the mast cells with degranulation[5,7] resulted (Table 1).

It is significant that activity of leucine aminopeptidase was demonstrable after treatment with Tyrode's solution. It is an open question whether or not this activity is connected with a release by mast cells. However, it should be noted that in a pretreated mesentery (Tyrode's solution or aqua bidest.) histochemically a real positive reaction of leucine aminopeptidase in mast cells could not be found. After osmotic disruption of the mesenteric mast cells by incubation in aqua bidest., the increase of activity of leucine aminopeptidase in the incubation fluid was about 100 per cent. This shows that osmotic rupture of the mast cells is concomitant with a release of leucine aminopeptidase.

It is still not possible to say, however, whether leucine aminopeptidase would be released in the process of physiological degranulation. Only suggestions can be made concerning the significance of leucine aminopeptidase in mast cells. Leucine aminopeptidase itself is probably not a uniform enzyme, but a mixture of di- and poly-peptidases[8]. Some observations[9,10] suggest that proteolytic enzymes, including leucine aminopeptidase, may be of importance in the process of liberation of heparin from native lipoprotein-complex[11,12] and perhaps also from the release of histamine or hydroxytryptamine. Also there may exist a relation to anaphylactic reactions, in which not only morphological changes in mast cells (degranulation) but also a higher activity of proteolytic enzymes can be found[13–15].

Table 1. Leucine Aminopeptidase Activity (in μgm. of Liberated β-Naphthylamine from L-Leucyl-β-Naphthylamide) in 0·5 ml. Fluid after Incubation (20 min. at 20° C.) of 1·0 gm. Rat Mesentery in 2·0 ml. Fluid

Rat	Incubation-fluid	
	Tyrode's solution	Aqua bidest.
1	220	422
2	263	423
3	248	395
4	244	417
5	238	421
6	227	409
7	243	449
8	231	422
	239 ± 13	420 ± 15

O. Braun-Falco
K. Salfeld

Hautklinik der Johannes Gutenberg-Universität,
Mainz.

Oct. 29.

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New Inhibitor and Erythrocyte Receptor Substances for Certain Asian Strains of Influenza Virus

Several investigators[1–5] and ourselves[6,7] have shown that individual Asian strains of influenza *A* virus can be divided into two groups on the grounds of their sensitivity to inhibitors of hæmagglutination. The so-called 'non-avid'[5] or *Q*-phase[8] strains are not inhibited by non-immune sera, and only moderately by homologous hyperimmune sera. On the other hand, both non-immune and immune serum inhibitors are highly active against the 'avid' or *R*-phase strains.

In the present work we investigated the factor responsible for the hæmagglutination-inhibiting activity of normal sera against the 'avid' Asian strains. The erythrocyte receptors were also studied. The spiral loop micro-technique described by one of us[9] was used in the hæmagglutination-inhibiting tests. The neutralization tests were performed in chorio-allantoic membrane cultures according to Horváth's method[10]. Fowl erythrocytes were used throughout.

Table 1 shows that none of the six animal species examined had serum inhibitors against the Singapore 1/57 strain, while all but the pooled mouse serum were highly inhibitory against Budapest 23/57, a representative of the 'avid' Asian strains. A sample of each of the sera listed in Table 1 had been boiled and vigorously stirred for 30 min., then centrifuged. The supernatants were tested. The hæmagglutination-inhibiting titres against the 'avid' strains were remarkably enhanced by boiling, while a nearly complete inactivation of the Francis and Chu inhib-

Table 1. COMPARISON OF THE HÆMAGGLUTINATION-INHIBITING TITRES OF NORMAL AND BOILED SERA

Sera	Virus strains							
	*PR*8		Lee		Sing. 1/57		23/57	
	a	*i*	*a*	*i*	*a*	*i*	*a*	*i*
	Unheated							
Human	32*	128	32	64	—	—	512	128
Rabbit	4	256	64	128	—	—	512	256
Guinea pig	—	128	8	64	—	—	1,024	512
Chicken	—	8	—	32	—	—	64	32
Ferret	—	4	—	16	—	—	256	256
Mouse	—	32	—	256	—	—	64	64
	Boiled for 30 min.							
Human	—	—	—	—	—	—	2,000	512
Rabbit	—	—	—	—	—	—	1,600	512
Guinea pig	—	16	—	16	—	—	6,400	5,000
Chicken	—	—	—	4	—	—	2,000	1,024
Ferret	—	—	—	—	—	—	2,000	1,024
Mouse	—	—	—	—	—	—	256	64

a, Active; *i*, inactivated at 56° C. for 30 min.
* Reciprocals of the hæmagglutination-inhibiting titres.

itors occurred as demonstrated by the disappearance of the hæmagglutination-inhibiting titres against active and heat-inactivated *PR*8 and Lee viruses. Boiled guinea pig sera had particularly high titres. The lowest temperature rendering sera more inhibitory against the 'avid' strains was dependent on the species; for example, heating to 56° C. for 30 min. was sufficient for guinea pig sera to develop higher hæmagglutination-inhibiting titres while sera of other species required considerably higher temperatures to become more effective. The 'non-avid' Singapore strain was not inhibited even by boiled sera.

Heating to 56° C. for 30 min. rendered *PR*8 and Lee virus preparations more sensitive to non-specific serum inhibitors but did not alter, or even lowered, the sensitivity of the 'avid' strains.

We have investigated some properties of the boiled inhibitor. It has been proved to be undialysable and biuret-positive; it is precipitated by 50 per cent acetone or 66 per cent ethanol; the precipitates can be re-dissolved without any loss in their inhibitory activity in saline; the inhibitor is completely precipitated in 0·35 saturated solutions of ammonium sulphate; digestion at 37° C. in a 0·25 per cent trypsin solution for 30 min. destroys its activity. Treatment of sera with crude cholera filtrate inactivated this inhibitor only partially and the Francis-type inhibitor had disappeared completely. Treatment with *M*/200 potassium periodate at room temperature for 3 hr. scarcely diminished the hæmagglutination-inhibiting titres of normal sera to the 'avid' strains, whereas those to the active and heat-inactivated preparations of *PR*8 and Lee viruses disappeared almost entirely. No carbohydrate could be detected in preparations purified by fractional precipitation with ammonium sulphate. The Molisch–Udránszky and the Antron tests were used.

Pre-epidemic human sera, as well as normal guinea pig sera, had also neutralizing titres against the 'avid' strains but not to the 'non-avid' Asian strains. The titres against 100 *ID*50 of an 'avid' strain attained 1 : 32 in pre-epidemic human and exceeded this level in normal guinea pig sera. Preliminary observations appear to suggest a direct relation between the hæmagglutination-inhibiting and neutralizing titres of normal sera. In a single experiment, however, boiling remarkably diminished the neutralizing capacity, in contrast to the simultaneous rise in the hæmagglutination-inhibiting titre.

Our results indicate that the 'avid' Asian strains are inhibited, and, to some extent neutralized, by a normal serum factor which is different from the non-specific inhibitors of hæmagglutination already described. The new inhibitor is supposed to be a thermostable protein or polypeptide.

The existence of a serum inhibitor reacting exclusively with the 'avid' Asian strains made reasonable a search for erythrocyte receptors supposed to be specific for those strains. The possible destruction of the receptors to the 'avid' strains by each of the strains *PR*8, Lee and Singapore 1/57 was examined first. Mixtures of virus and red cells were kept at 37° C. until the cells had become inagglutinable or barely agglutinable by all the strains tested except the 'avid' strains. The agglutinability by the latter was not altered by the above treatment. In further experiments red cells were treated with 'avid' strains in a similar manner. In these instances the rate of elution was slow, as compared with that of the 'non-avid' strains, and the red cells remained agglutinated even after extremely long incubation. We failed thus to obtain cell suspensions suitable for re-agglutination tests.

The effects of receptor-destroying enzyme as well as of potassium periodate on the red cell receptors reacting with the 'avid' strains were also studied. Using each of these treatments appropriately, we succeeded in obtaining cells of unaltered agglutinability by 'avid' strains but entirely inagglutinable by other strains of influenza virus.

Our preliminary results suggest that a receptor substance different from the red cell receptors to other strains of influenza virus is at least one of the substances responsible for the interactions between red cells and 'avid' strains of Asian virus.

We thank Dr. A. Isaacs, National Institute for Medical Research, London, for making available the Singapore 1/57 strain and crude filtrate of *V. cholerae*. A full account of this work will be published in the *Acta Virologica* (Prague).

GY. TAKÁTSY
K. BARB

State Institute of Hygiène,
Gyáli ut 2,
Budapest, 9.
Nov. 11.

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Effect of Brain Ganglioside on the Heart of the Clam

A PURIFIED preparation of brain ganglioside, a macromolecular glycolipid the structure of which has been recently considerably clarified[1], has been shown to inhibit in low concentration the viral hæmagglutination reaction[2] and to inhibit in the same concentrations the neurotoxic effect in mouse brain of influenza *PR*8 and *NWS* viruses[3]. The consideration of the possible membrane and transport role that brain ganglioside might have in the central nervous system has led to the investigation of the effect of this substance upon the heart of *Venus mercenaria* (clam), an organ which had been used in the bioassay of acetyl choline, 5-hydroxytryptamine, and other substances with known or suspected neurohumoral function[4,5].

The clam heart system employed was essentially that described elsewhere[5], with the exception that a 5-ml. bath was used. (We are grateful to Dr. M. K. Paasonen for demonstrating the method which he employs for bioassay with clam heart, and for a sample of 5-hydroxytryptamine creatine sulphate.) The bathing fluid consisted of sea water, with and without added benzoquinonium ('Mytolon'). Most preparations functioned well up to 10 and 15 hr., and stable function was established for at least 1 hr. before test substances were added. All hearts were highly responsive to 5-hydroxytryptamine creatine sulphate in the usual doses[5].

Both brain ganglioside salt and its ash-free derivative were employed[1]. Brain ganglioside salt in concentrations as low as 0·06 μgm./c.c. of suspension fluid produced a definite increase in the amplitude of contraction (12–30 per cent). At doses greater than 0·4 μgm./c.c. an increase in amplitude of contraction was accompanied by an increase in rate as well. At doses between 40 and 200 μgm./c.c. an increase in tonus also occurred, with definite raising of the baseline. At doses between 200 and 400 μgm./c.c. a tetanic state of contraction was observed. All the above effects were readily reversed by washing the heart with sea water. However, there appeared to be a cumulative effect in individual hearts on repeated administration of large doses of brain ganglioside, evidenced by a diminished responsivity to subsequent doses of brain ganglioside, although the heart retained normal responsivity to 5-hydroxytryptamine. Even while the heart was responding to brain ganglioside present in the bathing fluid, the addition of 5-hydroxytryptamine produced a superimposed stimulatory effect.

All these responses were observed whether or not benzoquinonium (6 μgm./c.c.) was present in the fluid. Since equivalent responses were obtained with both brain ganglioside salt, and ash-free brain ganglioside, the stimulatory effect does not appear to be dependent upon either the presence of a free or neutralized carboxyl group in the neuraminic acid of brain ganglioside. Neuraminic acid itself, obtained by hydrolytic cleavage of ash-free brain ganglioside[1], in doses of 60–120 μgm./c.c., produced a small increase in the amplitude of contraction comparable to the response obtained with only 0·06 μgm./c.c. of the intact brain ganglioside.

The active concentrations of brain ganglioside are low. Considering that the functional unit of this macromolecular substance is its structural repeating unit, molecular weight[1] approximately 3,314, then brain ganglioside is active in this system at concentrations of 10^{-8} molar. If, on the other hand, the functional unit is considered to be that indicated by the molecular weight determination of aqueous brain ganglioside (minimal molecular weight 250,000), then brain ganglioside is active at concentrations of 10^{-10} molar.

These findings, which will be described in detail elsewhere, together with the previous observations on the structure of brain ganglioside[1] and on its action in other biological systems[2,3], suggest the possibility that brain ganglioside may play a part in transmission phenomena in the central nervous system.

These studies have been supported in part by grants from the U.S. National Institutes of Health (*M*-2095 and *B*-1616).

SAMUEL BOGOCH
ELENORE S. BOGOCH

Neurochemical Research Laboratory,
Massachusetts Mental Health Center
(Boston Psychopathic Hospital),
and
Department of Psychiatry,
Harvard Medical School.

Nov. 5.

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Succinic Dehydrogenase Activity in Brain Tissue of Rats after Ovariectomy and Steroid Administration

ANÆSTHETIC properties of certain steroids have been demonstrated by Selye[1], and Michaelis and Quastel[2] have stated that anæsthetic activity depends on inhibition of the utilization of glucose and oxygen by brain tissue. Later, Gordan and Elliott[3] showed that addition of certain steroids to brain cells *in vitro* produced a prompt inhibition of the rate of uptake of oxygen by these cells. Conversely, in castrated male rats, that is, in animals deficient in gonadal steroids, the uptake of oxygen by the brain increased up to 35 per cent[4,5]—a fact which suggests that the steroids, by virtue of their inhibiting effects, act as brakes on cerebral metabolism. Further experiments indicated that the known anæsthetic potency of the steroids parallels their degree of inhibition[6]. The site of the steroid inhibition has since been found to be at the dehydrogenase-level rather[7,8] than the cytochromes, where other anæsthetic agents exert their effects. Thus, the distinctive effects of steroids on the respiratory metabolism of tissues can be ascertained by means of the quantitative analysis of the dehydrogenase activity under conditions of steroid administration or deficiency.

Scrutiny of the literature revealed that the results obtained on the influence of steroids on the oxygen uptake and respiratory enzyme activity were based upon experiments on male rats exclusively. In our previous experiments the activity of succinic and isocitric dehydrogenases in brain and other tissues under various experimental conditions were determined in male rats also[9].

Therefore, in the present experiments female rats were used and the succinic dehydrogenase activity of brain tissue under the conditions of ovariectomy and administration of gonadal hormones was assayed.

Seventy adult healthy female rats of the random-bred Hebrew University strain were spayed at the age of 2 months and divided into four groups. 15 animals were injected with 1 mgm. testosterone, 15 with 5 μgm. of œstradiol-benzoate and 15 with 1 mgm. of progesterone, whereas 25 ovariectomized rats received no injections. An additional group of 24 normal animals served as a standard of comparison. The injections were given for a period of 30 days and were discontinued 24 hr. prior to the examination. The dehydrogenase activity was quantitatively estimated by a modification of the Kun and Abood[10] tetrazolium method, developed in our laboratory[11]. The method is based on the degree of reduction of tetrazolium to the end-product, formazan, during the enzymic oxidation of succinate to fumarate and is estimated colorimetrically.

The modification is as follows. The incubation mixture contains 0·5 ml. of a 10 per cent tissue homogenate in potassium phosphate buffer, 0·25 ml. of a 0·08 *M* solution of sodium succinate substrate and 0·25 ml. of a 0·1 per cent solution of neo-tetrazolium chloride, at 37° C. for 20 min. By the addition of 2 ml. of a mixture of equal parts of ethyl acetate–ethanol, the reaction is stopped and the coloured end-product, formazan, is extracted. Thus the colour of the formazan solution is rendered stable for a relatively long period, and the reaction is suitable for estimating small quantities of enzymes —the modified procedure eliminating thereby the main drawbacks of the original method.

It can be seen from Table 1 that after ovariectomy the succinic dehydrogenase activity in brain tissue increased markedly. The different gonadal hormones administered exerted a distinctive influence on the succinic dehydrogenase activity of the brain in ovariectomized rats. All three steroids inhibited in a statistically significant degree (after ovariectomy) the elevated enzyme activity. Testosterone decreased this activity to the greatest extent, depressing it relatively far beneath the normal level; œstradiol effected a marked decrease from the normal degree, whereas progesterone, although exerting an inhibiting effect, levelled the enzyme activity to the normal values only.

Table 1. EFFECTS OF OVARIECTOMIZED AND GONADAL STEROIDS ON CEREBRAL SUCCINIC DEHYDROGENASE ACTIVITY

The figures express the amount of formazan (μgm.) produced by the enzyme during 20 min. of incubation at 37° C. in 1 ml. of 10 per cent tissue homogenate

Treatment	No. of animals	Age in months	Mean ± S.E.	Alteration (per cent)	*t*	*P*
Intact, female	24	3	526±18	—	—	—
Ovariectomized	25	3	623±27	+18·4	3·03	0·001
Ovariectomized+testosterone	15	3	329±48	−37·4	3·78	0·001
Ovariectomized+œstrogen	15	3	472±11	−10·2	2·57	0·02
Ovariectomized+progesterone	15	3	526±25	0	2·62*	0·02*
Intact, male	10	3	434±26	—	—	—

* These figures were calculated in relation to those of the ovariectomized, all the rest to the intact, animal.

In comparison with normal male rats of corresponding age the values for activity of succinic dehydrogenase in brain tissue of the intact female are somewhat higher. However, the increase of activity of succinic dehydrogenase after ovariectomy is similar to that observed in male rats after castration; the action of œstrogen as inhibiting the enzyme activity also corresponds to its effects in male. Contrary to these, the effect of testosterone is inhibitory in the female, while in the male this hormone increased still further the enzyme activity already elevated after castration[9].

Since corresponding effects of progesterone and testosterone in many instances, including anæsthetic actions, are known, the results obtained with progesterone administration were rather unexpected. In the present experiments this hormone was the least effective in decreasing the enzyme activity, in contrast to testosterone, which inhibited it to the greatest extent.

A full account of the experiments will be published elsewhere.

We are indebted to Mrs. J. Kidron for technical help.

H. SOBEL
B. ECKSTEIN

Department of Zoology,
Hebrew University,
Jerusalem.

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BIOLOGY

'Pheromones': a New Term for a Class of Biologically Active Substances

DURING the past few decades, investigations have been made into various active substances which, though they resemble hormones in some respects, cannot be included among them. For example, the sexual attractants of butterflies are, like hormones, produced and secreted by special glands; minute amounts cause a specific reaction in the receptor organ (the antenna of the male), which eventually leads to a state of copulative readiness. Unlike hormones, however, the substance is not secreted into the blood but outside the body; it does not serve humoral correlation within the organism but communication between individuals.

Referring to Starling's original definition, Bethe[1] called such substances 'ectohormones'; the name has been used by some authors but rejected by others. The most common definition of hormones to-day is that they are the products of endocrine glands. This should not be lightly expanded and diluted; in fact, it would be preferable to create and define a new term.

We propose, therefore, the designation 'pheromone' for this group of active substances. The name is derived from the Greek *pherein*, to transfer; *hormōn*, to excite. Pheromones are defined as substances which are secreted to the outside by an individual and received by a second individual of the same species, in which they release a specific reaction, for example, a definite behaviour or a developmental process. The principle of minute amounts being effective holds. The pheromones, messenger substances between individuals, thus take their place as a group beside the hormones, the gamones and the termones. Having stated that pheromones act on individuals of the same species, they must be differentiated from other stimulating substances, like phagostimulants, scents of flowers and insect repellents, which Bethe included among the ectohormones. Incidentally, strict species-specific activity is not required; certain overlaps between closely related species may occur.

There are various ways in which the recipient organism can detect pheromones. In a review shortly to be published, olfactory pheromones are distinguished from orally acting ones. The former, which can act over considerable distances, are perceived by chemoreceptors, from which nervous stimuli are sent to the central nervous system. If this released a certain behaviour, ethologists would place the pheromone concerned into the category of 'release stimuli'. The introduction of the term has been criticized for that reason (Verheijen-Voogd, C., personal communication). We nevertheless, on biological and biochemical grounds, regard it as sensible to mark off the pheromones from other chemical stimuli like food odours and others, and from optical, acoustic and similar releasers, as special messenger substances. It seems to us a fundamental difference whether an organism reacts to certain stimuli of the environment or creates for itself a means of communication of this kind. A clear definition of the pheromones and their specific action in particular cases should be of importance both to biochemical and to ecological research.

Among the active substances comprising the pheromones, most research has been carried out on those found in insects[2]. The queen substance of bees[3] and that of termites[4] inform the colony about the presence of the queen; if they are lacking, certain behaviour patterns and ovary development in the workers result. They act through the mouth, as do the active substances of the functional reproductives of termites, which inhibit the production of supplementary reproductives[5]. Should the hypothesis be confirmed, that royal jelly contains a specific developmental substance, formed in the lateral pharyngeal glands of the nurses, this, too, would be a pheromone. It is scarcely surprising that in the social insects in particular many pheromones are found, for these materials serve the social life of these animals.

The sexual attractants of butterflies and moths[6,7], cockroaches[8] and other insects, as well as the recognition odours of Hymenoptera[9,10], act through the olfactory sense. Lastly, the following substances also appear to fall into the category of pheromones: the sexual attractants of the Crustacea[11], the warning substance of the minnow[12], and probably also the territory-marking substances of the Carnivora, though here much remains to be solved.

The action of pheromones taken up orally can occur in two different ways. First, they can be perceived by the gustatory sense, thus making them absolutely analogous to the group of 'olfactory pheromones'. Apparently, the queen substance acts in this way (Butler, C. G., private communication). Secondly, there is the possibility that they may be resorbed in the digestive tract and develop their specific action by diffusing into the blood. This mode of action has not been proved in any special case. Therefore, we regard it as not yet expedient, or at least premature, to split the concept or make two definitions (for example, 'pheromones' acting through the senses and 'telemones' acting through the blood system). Chemoreception (basically a biochemical effect, too) and action of a hormone need not be contradictory; there are numerous examples of sensory stimuli or psychological excitations causing hormone secretion and of hormones releasing psychological states or behaviour patterns (nest building, parental behaviour). Finally, it is not easy to distinguish experimentally between sensory and biochemical effects, and therefore a clear classification is often just not possible.

The definition of pheromones has been discussed with several colleagues working in the field, and has found approval by A. Butenandt, Munich; C. G. Butler, Rothamsted; D. B. Carlisle, Plymouth; R. Chauvin, Burs-sur-Yvette; P. T. Haskell, London; B. Kullenberg, Uppsala; D. Schneider, Munich; R. Stumper, Luxemburg. We therefore throw the definition given above open for discussion and hope that it will prove itself in practice.

P. Karlson

Max-Planck-Institute for Biochemistry,
Munich.

M. Lüscher

Zoological Institute,
University of Bern. Nov. 12.

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Carotenoid Pigment in *Spirobacillus cienkowskii* Metchnikoff, a Pathogen of Cladocera

Cladocera are often coloured red by hæmoglobin in their blood[1]; another red pigment has been found in specimens infected by *Spirobacillus cienkowskii* which Metchnikoff[2] described from *Daphnia magna* Straus. The bacterium passes through a series of stages within the cladoceran and causes it to assume a bright red colour.

As a general rule less than 1 per cent of a cladoceran population shows signs of infection, but I have recently found a population of *Simocephalus vetulus* O. F. Müller in which up to 2 per cent of the individuals were infected. Several specimens of *Sida crystallina* (O. F. Müller) from the same body of water were also found to be infected with the same bacterium.

About three hundred infected specimens of *Simocephalus* were ground up in water and then centrifuged

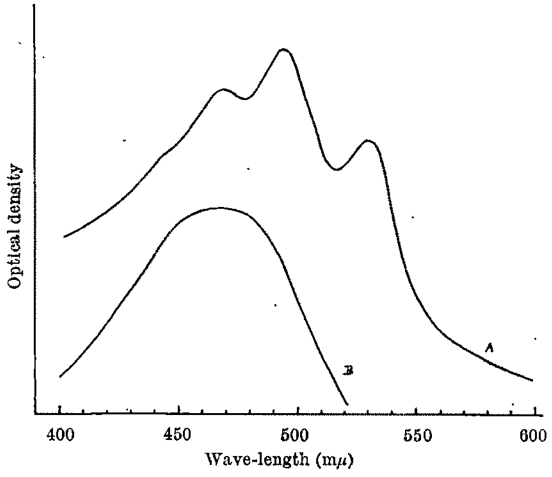

Fig. 1

at low speeds to leave a cloudy red suspension which consisted almost entirely of bacteria. When this suspension was centrifuged at 9,000 r.p.m. the bacteria were all spun down and a colourless fluid was left. This demonstrates that the pigment is confined to the bodies of the bacteria and is not a host reaction. The bacterial sludge was treated with acetone, when the pigment was easily extracted, then taken into petrol ether (boiling point, 60–80° C.) after dilution of the acetone with water. The solution in petrol ether was dried over anhydrous sodium sulphate and examined in a spectrophotometer. Absorption peaks were found at 470, 495 and 530 mμ (Fig. 1,*A*). The last two peaks are in fair agreement with those of rhodoviolascin and those of α-bacteriopurpurin, which is probably a demethylated form of rhodoviolascin[3]. The first peak is about 10 mμ too far towards the red end of the spectrum. The explanation for this was found when uninfected specimens of *Simocephalus* were treated in the same way as the infected specimens. An olive-green supernatant fluid was left after centrifuging; when this was treated with acetone it turned orange. The orange pigment was taken into petrol ether after dilution of the acetone water phase with more water. The absorption curve of the petrol ether solution is shown in Fig. 1,*B*. The single peak at 470 mμ agrees with that of astacene derived from astaxanthin which was present in the form of a green carotenoprotein. The presence of a small amount of astacene in the extract from the infected specimens would account for the apparent bathochromic displacement of the first peak of the bacterial pigment.

It is evident from these observations that the red pigment is a carotenoid of the α-bacteriopurpurin type, and that it is confined to the bacteria. There is an indication that the pigment is at least partially derived from carotenoid present in the host, because the patches of carotenoid protein which normally occur in healthy *Simocephalus* are changed to red when the pigment-bearing cells are infected with the bacterium.

J. GREEN

Zoology Department,
Bedford College, Regent's Park,
London, N.W.1. Oct. 27

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Adaptive Synthesis of Nitrate Reductase in Higher Plants

ADAPTIVE production of enzymes in higher plants is not widely recognized, although two examples have been reported[1]. Nitrate reductase systems are adaptive to nitrate and nitrite in micro-organisms[2,3] and studies with cauliflower[4] have suggested a similar adaptive character in higher plants. Tang and Wu[5] obtained more direct evidence of the adaptive character of this enzyme in rice seedlings germinated for five days under sterile conditions and Rijven[6] reported similar results for wheat embryos germinated for 24 hr. These experiments, however, involved relatively prolonged periods of contact between inducer and tissues undergoing both rapid cell division and expansion.

We have found in numerous tests that production of nitrate reductase activity can be rapidly induced in small fragments of leaves excised from cauliflower (*Brassica oleracea* var. *botrytis*), white mustard (*Sinapis alba*) and sunflower (*Helianthus annuus*). Fig. 1 shows results of experiments in which nitrate or molybdenum, or both, were introduced, by vacuum infiltration, into excised fragments of partially or fully expanded leaves of cauliflower grown in sand culture with ammonium sulphate or nitrate each with or without molybdenum. Rapid production of enzyme activity occurred on the introduction of nitrate into leaf tissues grown with ammonium sulphate, often apparently after a lag-period of about 1 hr. The introduction of molybdenum into leaves of plants deficient in molybdenum and grown with nitrate had a similar effect, resembling that observed in fungi[3]. Tissues of plants grown with ammonium sulphate but without molybdenum responded little or not at all to either factor alone, but rapidly developed activity when both were present.

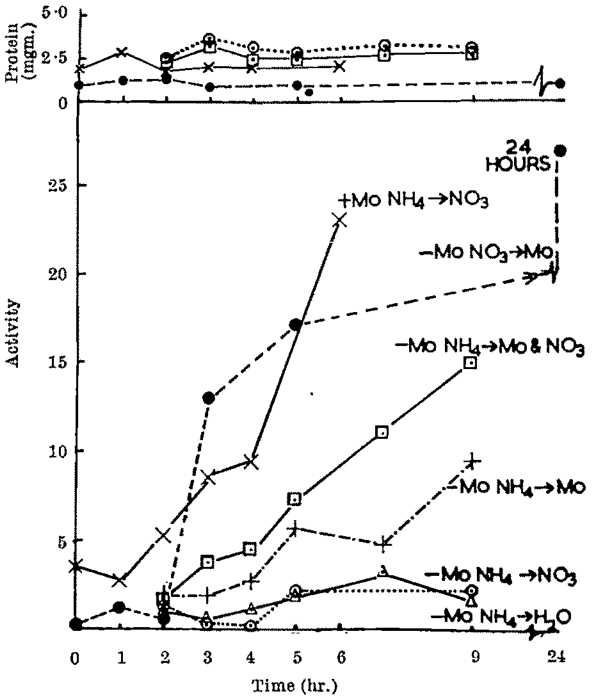

Fig. 1. Effect of infiltration with water, molybdenum, nitrate and molybdenum plus nitrate on the development of nitrate reductase activity (mμmole NO_2/15 min./mgm. protein) in excised leaf fragments of cauliflower grown with different nitrogen and molybdenum supplies. Mo at 5 μgm./ml. and NO_3 at 2·48 mgm./ml. in infiltrating solution

The increases in enzyme activity greatly exceed corresponding changes, if any, observed in soluble protein content. The conclusion that protein synthesis is involved in the production of enzyme activity is supported, however, from studies with antimetabolites, some of which are known to inhibit protein synthesis. Table 1 shows results for cauliflower and mustard obtained with actidione, 1 : 2-dichloro-4-(*p*-nitrobenzenesulphonylamido)-5-nitrobenzene (DCDNS) and polymyxin *B*-sulphate introduced simultaneously with the other factors. From the concentrations ranging between 20 and 300 μgm./ml. of inhibitors in the infiltrating solutions, we tentatively estimate that the concentrations resulting in the cells were of the order of 5×10^{-6} *M* for actidione and 7×10^{-5} *M* for 1 : 2-dichloro-4-(*p*-nitrobenzenesulphonylamido)-5-nitrobenzene. Polymyxin was present at 2 mgm./ml. in the infiltrating solutions. All three antimetabolites markedly

Table 1. Effects of Antimetabolites as Inhibitors of the Synthesis of Nitrate Reductase in Excised Leaf Fragments

(1) Plant and nutrient treatment during growth		(2) Infiltration • medium	(3) Activity (mμM NO_2/15 min./mgm. protein) in extracts prepared 6–9 hr. after infiltration with medium shown, with (+) or without (−) inhibitor, or with water (O) but omitting activating treatments in column (2):								
			Actidione			DCDNS			Polymyxin *B*		
			+	−	O	+	−	O	+	−	O
Cauliflower	− Mo NO_3	Mo	6·5	27·8	2·5	19·7	30·2	1·5	12·2	83·2	0·0
Cauliflower	− Mo NH_4	Mo + NO_3	3·5	29·0	0·0						
Mustard	− Mo NH_4	Mo + NO_3	11·2	61·0	1·5	5·0	61·0	1·5			
Mustard	+ Mo Urea	NO_3	20·7	64·0	24·0	22·9	52·0	29·0	28·2	67·0	40·2

inhibited the synthesis of the enzyme in intact tissues that were no longer undergoing cell division but which were probably capable of further cell expansion. The inhibition applied apparently equally to the adaptive effect of nitrate and to the determining influence of molybdenum on enzyme formation. There was no inhibition of activity *in vitro*. The question of absolute adaptive response to nitrate or of increased production of a constitutive enzyme remains unsettled at this stage.

Other antimetabolites, including *p*-fluorophenylalanine, β-2-thienylalanine, chloramphenicol, 8-azaguanine, 2-thiouracil, 5-methyl-2-thiouricil, streptomycin, aureomycin, neomycin, gramicidin, bacitracin and tyrothrycin, did not, as tested, inhibit the response either to molybdenum or to molybdenum and nitrate together. Chloramphenicol and aureomycin may, however, inhibit protein synthesis less in cell-free preparations from plants[7] than from bacteria, and even bacteria may show varying tolerance to the effect of chloramphenicol on the adaptive synthesis of nitrate reductase[8].

The results in Fig. 2 suggest that nitrate reductase is relatively labile *in vivo* and may decrease in excised or attached leaves with time unless stabilized by the continued presence of the substrate. Other experiments have shown that infiltration with the inhibitory antimetabolites alone, of tissues already possessing activity, causes a further marked decrease in activity with time as compared with the effects of water as control. It is possible, therefore, that the enzyme is de-adaptive and that there is a rapid 'turn-over' in terms of simultaneous synthesis and breakdown. In the absence of a significant substrate concentration there would be a steady net decrease, greatly accentuated in the presence of an inhibitor of synthesis.

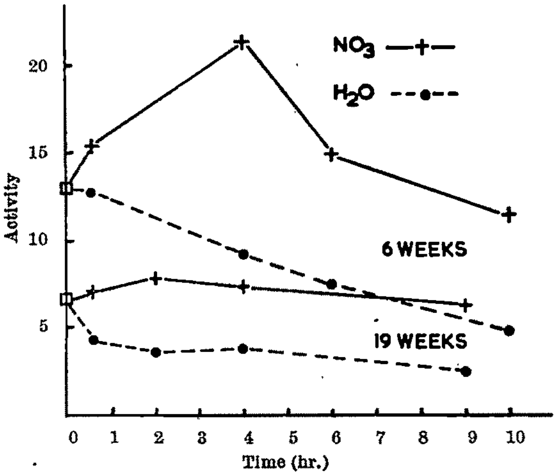

Fig. 2. Effect of infiltration with water or nitrate on the nitrate reductase activity (mμM NO_2/15 min./mgm. protein) of excised leaf fragments of cauliflower plants 6 weeks and 19 weeks old grown with molybdenum and nitrate. NO_3 at 2·48 mgm./ml. in infiltrating solution

The full details of this and continued investigations will be published elsewhere. We wish to thank Dr. D. W. Woolley of the Rockefeller Institute, New York, for a generous gift of 1 : 2-dichloro-4-(*p*-nitrobenzenesulphonylamido)-5-nitrobenzene. The award of a Colombo Plan Overseas Studentship to one of us (M. M. R. K. A.) is gratefully acknowledged.

E. J. Hewitt
M. M. R. K. Afridi
Agricultural Research Council
Unit of Plant Nutrition (Micro Nutrients),
Research Station,
Long Ashton, Bristol.

Oct. 11.

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Effects of Gibberellic Acid on Development of Autumn Colour and Leaf-fall of Deciduous Woody Plants

Gibberellic acid does not affect petiole abscission in *Coleus* explants[1], but we have found that treatment of some intact deciduous woody plants with gibberellic acid markedly influences development of autumn foliage colour and leaf-fall.

Gibberellic acid was applied as an aqueous spray (0·005 per cent gibberellic acid, 0·01 per cent 'Tween 20', 1·0 per cent glycerol) to all leaves of a selected branch on each plant; a comparable branch was sprayed with the inert constituents of the spray fluid, but on no occasion did this control treatment produce any observable effect as compared with unsprayed parts of the plant. The first application of spray was made on August 11, 1958, and thereafter at weekly intervals.

Little or no effect was noticed with *Acer rubrum* L., *Castanea sativa* Miller, *Fagus sylvatica* L., *Quercus robur* L., or *Ulmus procera* Salisb. Gibberellic acid delayed development of autumn colours and leaf-abscission in the following: *Acer pseudoplatanus* L., *Betula verrucosa* Ehrh., *Fraxinus excelsior* L., *Liriodendron tulipifera* L., *Parthenocissus tricuspidata* Planch., *Prunus avium* L .and a *Rhododendron* × *molle* cultivar. The most striking effects were noticed with *Fraxinus excelsior*, *Prunus avium* and *Acer pseudoplatanus*; all leaves were still quite green on November 21, whereas all leaves from untreated branches had fallen. Only slightly less striking was the effect on *Liriodendron tulipifera*; on November 21 nearly all treated leaves were still green, whereas all other leaves remaining on the tree were bright yellow.

In complete contrast, development of autumn colour and abscission of short shoots and leaves of *Taxodium distichum* Rich. was advanced by treatment with gibberellic acid. The leaves turned bronze in colour shortly after the first treatment, and all leaves on treated branches had fallen by October 20; whereas bronzing of leaves on untreated branches was only beginning at that date, and leaf-fall was only partial on November 21.

Shoot extension had ceased in most of these plants at the time of the first treatment. Lateral and apical buds resumed activity, and new shoots and leaves were formed as a result of treatment with gibberellic acid in *Acer pseudoplatanus*, *Betula verrucosa* and *Liriodendron tulipifera*.

Thus most species treated with gibberellic acid gave one or more of the following responses: delay in development of autumn foliage colour, delay of leaf-abscission, renewal of shoot growth. These are characteristic responses to long-day conditions[2,3], and this result affords one more example of the induction by gibberellins of typical long-day responses[4]. The anomalous result with *Taxodium distichum* awaits explanation.

P. W. Brian
J. H. P. Petty
P. T. Richmond

Akers Research Laboratories,
Imperial Chemical Industries, Ltd.,
Welwyn, Hertfordshire.
Nov. 27.

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Gibberellin Effects on Photoperiod-controlled Growth of *Weigela*

Weigela, a woody ornamental plant, produces uninterrupted vegetative extension when grown at photoperiods in excess of 14 hr., whereas at shorter photoperiods (<14 hr.) vegetative growth ceases, and the plant enters a dormant condition[1-3]. This communication describes the replacement of the photoperiodic requirement for the vegetative development of *Weigela* with gibberellin applied to plants grown under a short photoperiod, and the acceleration of growth under a long photoperiod.

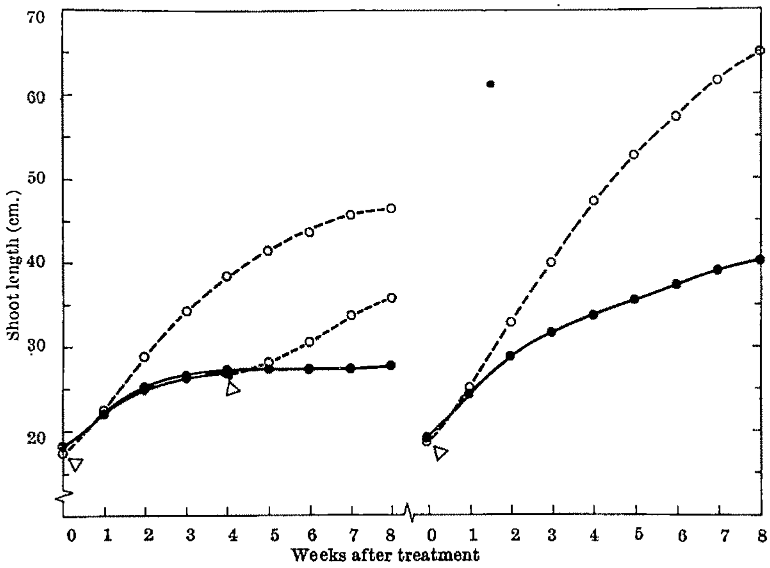

Fig. 1. Growth-rate curves illustrating the effect of gibberellin on the vegetative extension of *Weigela* cl. 'Vanicek' grown at 9-hr. (left) and 18-hr. (right) photoperiods. ○ - - - ○, treated with gibberellin; ●——●, untreated. △, Time of treatment with gibberellin

Two-year-old plants of *Weigela* cl. 'Vanicek' were grown in pot cultures in a greenhouse at an 18-hr. photoperiod and 16° C. night temperatures until growth-rates were well established (shoot elongation of 4·0 cm./week). Plants were selected for uniformity, pruned to five vegetative shoots, and six plants subjected to each of the following treatments: (*a*) retained at an 18-hr. photoperiod; (*b*) treated with gibberellin and retained at an 18-hr. photoperiod; (*c*) transferred to a 9-hr. photoperiod; (*d*) treated with gibberellin and transferred to a 9-hr. photoperiod; (*e*) transferred to a 9-hr. photoperiod and treated with gibberellin after dormancy was induced (4 weeks). Gibberellin treatment consisted of a single foliar spray of 50 p.p.m. (acid equivalent) of potassium gibberellate (potassium gibberellate was presented by Merck and Co., Inc., Rahway, N.J.) plus 0·1 per cent 'Tween 20' (polyoxyethylene sorbitan monolaurate supplied by courtesy of the Atlas Powder Co., Wilmington, Delaware) as a wetting agent. All plants were exposed to 9 hr. of natural daylight. Those under an 18-hr. photoperiod were exposed for an additional 9 hr. to artificial light (30 foot-candles from 60-watt incandescent-filament lamps).

A single foliar spray (50 p.p.m.) of gibberellin on *Weigela* subjected to the 9-hr. photoperiod resulted in continued shoot elongation during the course of the experiment. Comparable plants not treated with gibberellin ceased vegetative extension (Fig. 1, left), and formed rosettes after three weeks. Dormancy, induced by a short (9-hr.) photoperiod, was broken, and growth-rates in excess of those in non-treated plants grown at an 18-hr. photoperiod were established. After eight weeks the length of shoots on plants treated with gibberellin at the 9-hr. photoperiod exceeded that of the non-treated plants at the same photoperiod by 65 per cent. The growth of shoots of the treated plants in the short photoperiod (treatment *d*) compared favourably with, and even exceeded (by 15 per cent) those for the non-treated plants retained at the 18-hr. photoperiod (treatment *a*). Thus, the photoperiodic requirement for vegetative elongation and breaking the photo-induced dormancy was replaced with gibberellin. The effect of gibberellin, at the short photoperiod, began to diminish after 3 or 4 weeks as indicated by the decreasing growth-rate.

Gibberellin also promoted growth in *Weigela* at the 18-hr. photoperiod, and this increased rate of growth was maintained throughout the experiment (Fig. 1, right). Growth of shoots, eight weeks after gibberellin treatment, at the 18-hr. photoperiod, exceeded that of the non-treated plants by 63 per cent.

The gibberellin-promoted increase in shoot extension at the 18-hr. photoperiod was primarily attributed to an increase in length of internodes, while at the 9-hr. photoperiod both length and the number of nodes were increased.

Leaves on treated plants were generally longer, narrower, and paler green than those on non-treated plants at both photoperiods.

Gibberellin applied to *Weigela* plants grown under a 9-hr. photoperiod induced growth of shoots and broke the photo-induced dormancy, hitherto possible only with long photoperiods. Furthermore, gibberellin accelerated the rate of growth of *Weigela* when grown under a photoperiod conducive of continuous vegetative extension.

MARTIN J. BUKOVAC
HAROLD DAVIDSON

Department of Horticulture,
Michigan State University,
East Lansing,
Michigan. Oct. 20.

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Interaction between Kinetin and Indoleacetic Acid in the Control of Bud Reactivation in *Splachnum ampullaceum* (L.) Hedw.

It has been shown[1] that the apical region of the gametophore of *Splachnum ampullaceum* (L.) Hedw. inhibits both lateral bud reactivation throughout the gametophore and protonematal regeneration from the base of the gametophore. These apical dominance effects could be replaced by the application of indoleacetic acid to the tips of decapitated plants.

Recently, Wickson and Thimann[2] presented evidence which indicates that apical dominance in *Pisum sativum* in terms of the inhibition of lateral bud reactivation is governed by an interaction of kinetin or kinetin-like factor and auxin.

The experiments described in the present communication were undertaken with the following questions in mind: (1) Is an interaction between kinetin and auxin similar to that found by Wickson and Thimann responsible for reactivation phenomena in the gametophore ? (2) If so, are the mechanisms of correlation inhibiting lateral bud reactivation and protonematal regeneration from the base of the gametophore identical or different for these apical dominance effects ? This question remained an open one in the investigation mentioned above[1].

The male strain of *Splachnum ampullaceum* was used. Plants were reproduced vegetatively and the gametophores treated were always 20–21 days old. They were grown on Beijerinck's inorganic solution plus 1 per cent agar. The *p*H of the medium was adjusted to 6·0. The plants were kept under continuous artificial illumination with fluorescent (daylight) lamps. The compounds tested were administered in small blocks containing 2 per cent agar placed on the tips of decapitated plants immediately following decapitation. Lateral bud reactivation and basal regeneration were examined four days after the beginning of the treatment. The blocks were changed twice per day over the four-day period. The amount of bud reactivation realized was taken as number of branches/number of axils × 100. The results are given in Table 1. Kinetin was obtained from the H. M. Chemical Co., Ltd., Santa Monica, California.

Table 1. LATERAL BUD REACTIVATION AND PROTONEMATAL REGENERATION FOUR DAYS AFTER THE BEGINNING OF TREATMENT

Treatment	Percentage of bud reactivation	Reactivation of basal bud*	Length of longest branch (mm.)	No. of protonemata
Intact	0	0	—	28
Decapitated + water	84	70	0·418	46
Decapitated + IAA (1 mgm./ml.)	0	0	—	31
Decapitated + K (1 mgm./ml.)	90	100	0·350	41
Decapitated + IAA (1 mgm./ml.) + K (1 mgm./ml.)	79	80	0·291	33
Decapitated + IAA (1 mgm./ml.) + K (1×10^{-1} mgm./ml.)	60	40	0·258	31
Decapitated + IAA (1 mgm./ml.) + K (1×10^{-2} mgm./ml.)	45	10	0·220	30
Decapitated + IAA (1 mgm./ml.) + K (1×10^{-3} mgm./ml.)	42	0	0·125	29

*Determined as number of most basal branches/10 plants × 100.

It may be seen from these results that the apical region inhibits lateral bud reactivation completely at this stage of gametophore development and that it has a depressing effect on the realization of regenerative potentialities at the base of the gametophore. Both these apical dominance effects can be replaced by the application of indoleacetic acid (IAA) at the given concentration to the tip of the decapitated gametophore. Kinetin (K) is seen to have a strong antagonistic effect on the action of indoleacetic acid in that it promotes lateral bud reactivation in the presence of indoleacetic acid. Kinetin does not seem to have any effect in counteracting the action of indoleacetic acid on basal regeneration.

These results indicate, therefore, that an interaction between kinetin and indoleacetic acid may control reactivation of lateral buds in the gametophore similar to the situation described by Wickson and Thimann for *Pisum sativum*. Since kinetin does not counteract the effect of the apex or indoleacetic acid on the depression of basal regeneration, it may be concluded that the mechanisms of correlation mediating apical dominance in terms of the inhibition of lateral bud reactivation and the depression of basal protonematal regeneration are not identical.

Since both kinetin and indoleacetic acid have to migrate from the tip of the decapitated plant to its base, the site of protonematal regeneration, it could be maintained that the failure of kinetin to counteract the effect of indoleacetic acid in this latter phenomenon may be due to differences in the translocation of these two compounds, for example, due to differences in inactivating principles. To test this possibility, the percentage of reactivation of the most basal bud was examined for the various treatments. The results are given in the second column of Table 1. They indicate that kinetin also antagonizes the inhibitory effect of indoleacetic acid on reactivation in the most basal bud. Since this bud is rather close to the base of the gametophore, the site of basal regeneration, it may be concluded that differences in translocation between the two compounds probably cannot be the basis for the ineffectiveness of kinetin in counteracting the inhibitory effect of indoleacetic acid on basal regeneration. Hence the mechanisms governing correlative inhibition of lateral bud reactivation and basal protonematal regeneration by the apical region of the gametophore appear to be different from each other.

It should be mentioned here that Gorton and Eakin[3] have investigated gametophore initiation in the protonemata (induction of "dauermodifikation"[4]) of *Tortella caespitosa*. Bud initiation was found here to be inhibited by high concentrations of auxin, and was strongly stimulated by kinetin. Kinetin reversed the inhibition of bud formation brought about by napthalene acetic acid. It seems, therefore, that certain stages in the induction of "dauermodifikation", that is, bud initiation in the protonemata, and lateral bud reactivation in the gametophore may be mediated by the same mechanism.

This study was supported by a grant from the National Research Council of Canada. Technical assistance by Miss Veronika Ruf is gratefully acknowledged.

K. E. von Maltzahn

Botanical Laboratories,
Dalhousie University,
Halifax, Nova Scotia.
Oct. 21.

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Temperature and Symbiotic Nitrogen Fixation

Moderately high temperatures have been found to exert a specific inhibitory effect on symbiotic nitrogen fixation. The results of an experiment illustrating this effect are given in Table 1.

Table 1. Effect of Temperature, Inoculation with *Rhizobium*, and Potassium Nitrate on the Yield and Percentage Protein Nitrogen of Subterranean Clover (Means of Four Replicates)

Treatment	Yield of dry matter per tube (mgm.)		Protein nitrogen in plants (per cent)	
	20° C.	30° C.	20° C.	30° C.
Without nitrogen or *Rhizobium*	38·0	35·2	1·35	1·54
Inoculated with *Rhizobium*	54·5	35·3*	2·66	1·69*
With potassium nitrate	56·8	62·0	2·59	2·55
Standard error expressed as percentage of mean	4·9 per cent		4·3 per cent	

* Interaction between form of nitrogen (*Rhizobium* v. potassium nitrate) and temperature is significant at $P < 0{\cdot}001$ for both yield and percentage protein nitrogen.

For this experiment, subterranean clover (*Trifolium subterraneum* L. var. Bacchus Marsh) plants were grown on nitrogen-free nutrient agar in test-tubes which were stood in temperature-controlled water-baths in a glasshouse. The results show that the uninoculated plants responded normally to nitrogen treatment at both temperatures. By contrast, plants inoculated with *Rhizobium* fixed nitrogen and grew normally only at the lower temperature. The inoculated plants were well nodulated at both temperatures. Thus the symbiotic nitrogen fixation process was specifically inhibited at the higher temperature.

We have investigated the hypothesis that this inhibitory effect of high temperature is due to a decrease in the supply of soluble carbohydrate to the nodule, resulting from an increase in the rate of respiration. The addition of sucrose to the culture medium in aseptic cultures did not increase the amount of nitrogen fixed at either the high or low temperature. The sucrose increased the yield of the plants but decreased the percentage nitrogen, indicating that the added sucrose was taken up by the plants but was not required directly for nitrogen fixation. We have therefore begun to examine the possibility that the high temperature has induced the deficiency of some other metabolite essential for symbiotic nitrogen fixation.

These findings also raise a number of other interesting problems. One of these concerns the reported harmful effects of high light intensity on symbiotic nitrogen fixation. This was first reported as long ago as 1935[1,2], when shading was shown to have a remarkable effect in breaking the nitrogen-hunger period in legumes. This response to shading was interpreted in terms of an effect on light intensity and photosynthesis. In our experiments we have been able to obtain marked responses and apparently normal growth of clover under the conditions of high light intensity of our summer by cooling the plants. It would appear that there is a need to determine in greater detail the relative effects of high temperature and high light intensity on symbiotic nitrogen fixation.

The significance of these findings in relation to the culture of legumes under experimental and field conditions is also an important matter for investigation. We have evidence that these effects are of importance in the culture of legumes in glasshouses in warmer weather, not only where the plants are grown in test-tubes, but also for larger pots. In fact the present work arose from observations made during the course of a pot culture experiment conducted during 1957, when it was found that subterranean clover grown in soil in pots made of clear polystyrene plastic were stunted and pale green in comparison with the larger dark green plants in corresponding enamelled pots. The reason for this difference was traced to the considerably higher soil temperature in the clear plastic pots. Since becoming aware of this effect we have obtained unmistakable evidence of suboptimal symbiotic nitrogen fixation in clover grown in various kinds of pots where soil temperatures have exceeded about 25° C.

We have no direct evidence on the possible effects of high temperatures on symbiotic nitrogen fixation under field conditions. In view of the temperatures involved it would seem that such effects may be of significance, particularly under irrigation in the warmer months, or in tropical and sub-tropical environments.

Full details of the experiments that have been done on this problem will be published elsewhere.

D. R. Meyer
A. J. Anderson

Division of Plant Industry,
Commonwealth Scientific and
Industrial Research Organization,
Canberra.
Sept. 25.

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Electrophoretic Patterns of Mealworm Proteins

THE literature concerning insect proteins is, generally, represented by analyses of single developmental stages, usually immature, hæmolymph being the principal fluid investigated. The results of these studies show that the protein component fluctuates during development[1-4]. This communication shows the variations for the protein component of the mealworm *Tenebrio molitor*, during its developmental stages. The method employed, electrophoresis, seems to be a useful facility for investigations of this nature, since electrophoretic patterns of proteins are distinctive. Specific pattern characteristics have been reported for developmental stages of mammals[5], closely related species of reptiles[6,7], and amphibians[8,9].

The insects were raised in the laboratory on a diet of chicken mash and grain and a daily ration of water. Eggs, laid in white flour, were harvested daily, and white larvæ, pupæ and adults were collected within one hour following their emergence. In this manner timed records were maintained for each phase of the life-cycle. Approximately 100 mgm. of eggs, newly emerged and 14-day-old larvæ were separately homogenized in 1 ml. of water in a tissue homogenizer. The posterior abdominal segment of pupæ and adults was severed and the body contents extruded into separate weighing vials containing 1 ml. of water until 100 mgm. had been collected. The samples were centrifuged and the supernates retained for electrophoresis. 0·02-ml. volumes of extract were applied to Whatman No. 1 filter paper strips for analysis ('Spinco' electrophoretic system, barbital buffer *p*H 8·6, ionic strength 0·05, 5 m.amp., 16 hr.). The strips were dried at 120° C. for 30 min., stained with light green *SF*[10] and scanned with a recording densitometer ('Spinco Analytrol').

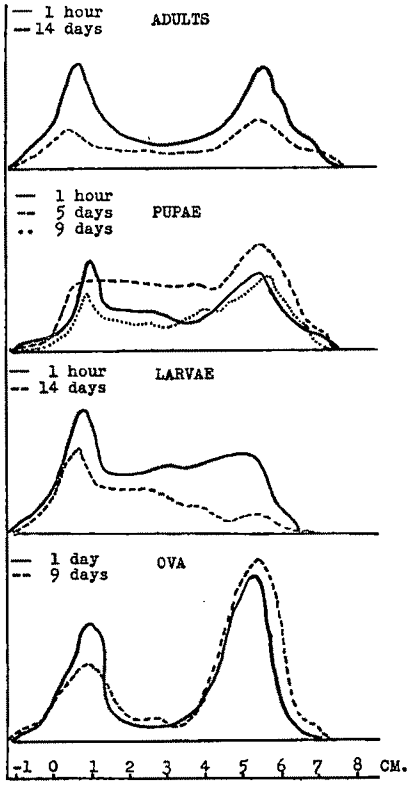

Fig. 1. Paper electrophoresis patterns of the mealworm *Tenebrio molitor*, at various stages of development. Extract, 0·02 ml., was applied at 0 cm.; anode is to the right

The electrophoretic patterns in Fig. 1 show two distinct anodal fractions for all stages except[7] the 14-day-old larvæ. The slower migrating fraction shows a well-defined band between −1 and 1 cm. from the point of origin. The faster fraction is well resolved between 4 and 6 cm. from the point of origin.

A comparison of the four stages discloses a uniformity in pattern for the slow fraction. Its concentration decreased as each phase of the developing mealworm progressed towards maturity. The fast fraction patterns are more variable. The peak is greater than that of the slow fraction for the egg and 5-day-old pupæ, approximately equal for the adults and the 9-day-old pupæ, and lower for the remaining groups. The eggs and pupæ also show alternation of the high peaks for the two fractions during their respective growth periods. A similar pattern prevails for the 1-hr. and 5-day-old pupæ. The trough separating the two peaks is relatively low for the ova and adults. The mid-pattern of the pupæ depicts a distinct rise and fall in concentration with increasing age.

These results show, generally, the direction of change for each stage of development and suggest the influence of basic growth activities. The results display the same type of variation as do morphological and physiological factors in bringing about protein changes in response to a modification of immature tissues for the subsequent building of the mature structure.

This study suggests the value of paper electrophoresis in revealing characteristics of insect proteins for investigating the comparative physiology of life-cycle activities.

D. S. PO-CHEDLEY

D'Youville College,
Buffalo, 1,
New York.
Oct. 17.

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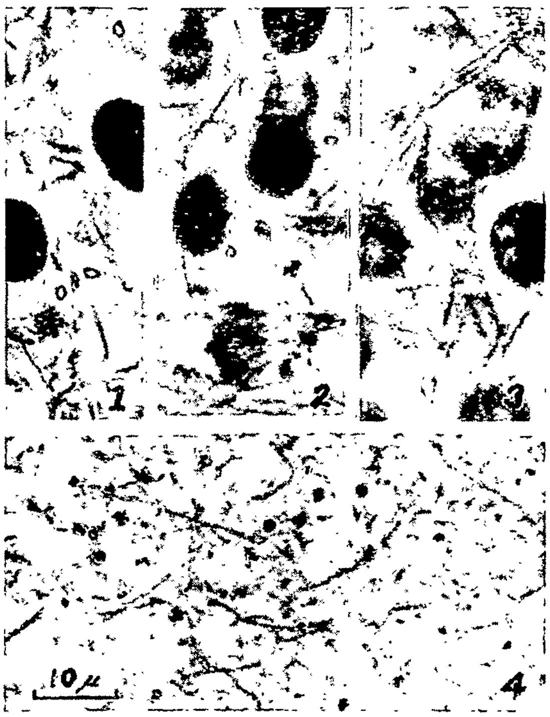
Environmental Temperature and the Reptilian Nervous System

IT has been found that the terminal plexus of the reptilian brain undergoes marked changes with the environmental temperature.

Lizards (*Lacerta viridis*) have been kept at 19° C. and at 32 ± 3° C. for periods up to 8 weeks. Some of the animals (twenty-four) were killed by perfusion with saline followed by 10 per cent neutralized formol saline under ether or urethane anæsthesia, and the brains were prepared by the Holmes method. Other



Figs. 1 and 2. The large-celled layer of the hippocampus. Animal kept at 19° C.

Fig. 3. The large-celled layer of the hippocampus. Animal kept at 32° C.

Fig. 4. The nucleus sphæricus. Animal kept at 32° C. All figures taken from Holmes's preparations at the same magnification

animals (five) were decapitated under ether anæsthesia and the brains prepared by the Nonidez technique. Observations have been confined to the large-celled layer of the hippocampus, the nucleus sphæricus (posterior hypopallium) and the nuclei of the seventh and eighth cranial nerves.

Lizards that had been kept at 19° C. for 8 weeks showed a large number of well-stained terminal rings and a few swollen fibres distributed among the cells of the large-celled layer of the hippocampus and in the cranial nerve nuclei (Figs. 1 and 2). The fine-fibre plexus of the nucleus sphæricus showed irregular staining suggestive of degenerative changes.

Animals that had been kept at 32 ± 3° C. showed relatively few rings in any of the cell groups investigated (Fig. 3). In the nucleus sphæricus a number of solid blobs 1–3μ in diameter appeared in the irregularly stained fibre plexus (Fig. 4). These blobs only appeared after the animals had been kept at 32° C. for about three weeks. They continued to increase in size and number up to eight weeks.

Lizards obtained fresh from the dealers showed the typical cold picture in some groups of animals and an intermediate picture in others.

These differences are independent of the anæsthetic or the method of preparation. It is probable that they are related to the neurofibrillar thickening that Tello[1] and Cajal[2] found in hibernating reptiles.

The changes that have been found may give further information about the nature of the finer terminals. Some of the appearances of rings, swollen fibres and blobs are suggestive of degeneration in fine terminal ramifications and could be mistaken for degeneration products of experimental lesions.

We wish to thank Miss B. Shirra for the histological preparations and Mr. J. Armstrong for the photographs.

B. B. BOYCOTT

Zoology Department,

R. W. GUILLERY

Anatomy Department,
University College London,
Gower Street,
London, W.C.1.
Oct. 24.

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A Hepatotoxin from *Sporidesmium bakeri* capable of producing Facial Eczema Diseases in Sheep

A PREVIOUS communication[1] reported that spores of a fungus identified as *Sporidesmium bakeri* Syd. contained the 'beaker test' substance found to be associated with toxicity of pasture samples on which the disease known as facial eczema had occurred.

In initial experiments mycelial felts grown on Raulin–Thom and Czapek–Dox media failed to produce liver lesions when fed to guinea pigs. The material so fed was also negative to the 'beaker test'. Subsequent experiments with a high-sporing strain of the fungus, grown on potato–carrot extract medium, produced liver damage in guinea pigs, indistinguishable from that obtained after feeding hepatotoxic grass. The material fed comprised a mixture of mycelial felts, spores and medium. Similar fungal material produced liver lesions characteristic of facial eczema in lambs. Later a clinical case showing typical icterus and photosensitization was produced.

The specific nature of the liver lesions was diagnosed in both guinea pigs and lambs by D. C. Dodd, of Ruakura. The assistance is acknowledged of D. J. Ross of the Soil Bureau and W. Crawley of Ruakura in cultural methods and E. P. White of Ruakura in chemical work.

Experiments are being planned to determine whether the hepatotoxin of this fungus is also responsible for facial eczema as it occurs in the field.

R. H. THORNTON

Biology Division,
Soil Bureau,
Department of Scientific and Industrial Research,
Wellington, New Zealand.

J. C. PERCIVAL

Ruakura Animal Research Station,
Department of Agriculture,
Hamilton, New Zealand.
Nov. 5.

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A Bacterium with Fungicidal Activity

IN a recent communication, Percival and Thornton[1] referred to the relationship between fungal spores and a test for hepatotoxic grass. It has since been shown that the fungus is *Sporidesmium bakeri* Syd. and is the source of the hepatotoxin which causes the specific liver damage which occurs in the disease known as 'facial eczema'. In connexion with this work, we have isolated a strain of *B. subtilis* which has a marked inhibitory effect on the growth of this fungus on culture media. Further investigations are being carried out to determine its spectrum of antibiotic activity and its relationship to the fungus in the field.

W. E. CRAWLEY
D. C. DODD

Ruakura Animal Research Station,
Department of Agriculture,
Hamilton,
New Zealand.

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Rutin in Tobacco grown in a Greenhouse

IT has been reported[1-3] that leaf from tobacco grown in a greenhouse contains no rutin and in general much less polyphenolic material than leaf from plants grown in the field, and it has been concluded that the filtering action of the greenhouse glass to ultra-violet irradiation is responsible for certain of these differences. However, Frey-Wyssling and Bäbler[1] were able to show that when greenhouse plants were irradiated with ultra-violet light the chlorogenic acid content of the leaves was increased, but that rutin was still absent, which implies that the apparent absence of rutin is not due to limited ultra-violet irradiation.

We have recently experimented in this Department with the flue-cured tobacco variety Hicks in order to see if satisfactory leaf can in fact be grown under glass. The plants were grown both in clay pots and polyethylene buckets containing washed quartz sand using the nutrient solution developed by McEvoy[4] supplied by means of a drip-feed system. The plants were handled in a similar manner to tobacco grown in the field; they were topped at sixteen leaves and suckers were removed as they appeared. The leaves were harvested as they became mature and cured in a small cabinet. After curing, the leaves had the appearance of tobacco grown in the field, and comparable plant yields were obtained.

Aqueous extracts of the green and cured leaves were examined for polyphenols by means of one- and two-dimensional paper chromatography[5], and in agreement with other workers it was found that the total amount of polyphenolic compounds was less than in field-grown tobacco. However, rutin (quercetin-3-rhamnoglucoside) was present in the extracts. No other flavonols or flavonol glycosides could be detected on the chromatograms. A useful spray reagent for the detection of flavonols consists of a freshly prepared mixture of equal volumes of boric acid (1 per cent in acetone) and citric acid (10 per cent in acetone). With this reagent the rutin spot turns yellow and shows a greenish-yellow fluorescence under ultra-violet light.

The rutin contents of several samples of cured greenhouse-grown tobacco were determined using a modification (Weaving, A. S., unpublished method) of the methods proposed by Wilson[6] and Guseva and Nestyuk[7]. It may be mentioned here that the method used by Turner[8] was not suitable owing to the interference by chlorogenic acid. The results obtained are given in Table 1 and are expressed on a moisture-free basis.

Table 1. RUTIN CONTENTS OF GREENHOUSE-GROWN TOBACCO

	Clay pot (per cent)	Polyethylene bucket (per cent)
Third harvest	0·24	0·23
Fourth harvest	0·24	0·24
Fifth harvest	0·29	0·28
Sixth harvest	0·37	0·33
Seventh harvest	0·39	0·43

These rutin contents are much lower than those of field-grown flue-cured tobacco, for which we have found values ranging from 1·0 to 1·7 per cent (Weaving, A. S., unpublished results).

It has been shown by Penn and Weybrew that cultural and curing practices can greatly influence the polyphenol content of tobacco grown in the field, and this aspect is now under investigation with greenhouse plants.

Thanks are due to the Directors of the Imperial Tobacco Company (of Great Britain and Ireland), Ltd., for permission to publish this communication.

T. P. FERGUSON
A. S. WEAVING

Research Department,
The Imperial Tobacco Co:, Ltd.,
Raleigh Road,
Bristol 3. Nov. 6.

[1] Frey-Wyssling, A., and Bäbler, S., *Experientia*, **13**, 399 (1957).
[2] Penn, P. T., and Weybrew, J. A., *Tobacco Sci.*, **2**, 68 (1958).
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HISTORY OF SCIENCE

Inertial Navigation

THE recent voyage of the submarine *Nautilus* below the polar ice has caused interest to be focused on the subject of 'inertial navigation'. This recalls to mind a communication which was published in *Nature* (7, 483; 1873). A correspondent, Joseph John Murphy of Co. Antrim, discounted the idea that "the instinct of direction in animals is of the same kind as the faculty by which men find their way" and suggested instead a mechanical analogy basically identical with 'inertial navigation', namely:

"If a ball is freely suspended from the roof of a railway carriage it will receive a shock sufficient to move it, when the carriage is set in motion: and the magnitude and direction of the shock . . . will depend on the magnitude and direction of the force with which the carriage begins to move . . ." ". . . every change in . . . the motion of the carriage . . . will give a shock of corresponding magnitude and direction to the ball. Now, it is conceivably quite possible, *though such delicacy of mechanism is not to be hoped for* [my italics, D. C.], that a machine should be constructed . . . for registering the magnitude and direction of all these shocks, with the time at which each occurred . . . from these data the position of the carriage . . . might be calculated at any moment."

Murphy went on to detail the possible mechanism by reference to the recording anemometers of his day, and even suggested dial indication of instantaneous distance and direction from the starting point.

D. CHILTON

Department of Astronomy and Geophysics,
Science Museum,
London, S.W.7.
Oct. 9.

FORTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

Monday, January 5

Photobiology Group (in Room 179, Darwin Block, Bedford College, Regent's Park, London, N.W.1), at 2 p.m.—Scientific Papers.

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. H. T. Prior, Mr. D. J. R. Chapman and Mr. A. A. M. Whitehead: "The Application of Transistors to Line Communication Equipment".

Society of Instrument Technology, Control Section (at Manson House, Portland Place, London, W.1), at 6 p.m.—Mr. J. C. Kubale: "Control Systems as Applied to Railways Signalling".

Society of Chemical Industry, London Section (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. C. M. Berners-Lee: "Some Uses of Electronic Computers in the Chemical Industry".

Tuesday, January 6

Royal Aeronautical Society (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 3 p.m.—Dr. L. R. Shepherd: Lecture on Astronautics.

Institution of Chemical Engineers—(at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. Ll. Rees and Mr. F. J. R. Taylor: "Feed Water and Boiler Water Standards in the Central Electricity Generating Board"; Mr. J. Arthurs, Mr. J. A. Robins and Mr. T. W. Whitefoot: "The Treatment of Water for an Industrial High Pressure Boiler Plant".

Institution of Electrical Engineers, Measurement and Utilization Sections (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. H. Davis: "Silicone Electrical Insulation".

Institution of Mechanical Engineers, Internal Combustion Engine Group (at 1 Birdcage Walk, Westminster, London, S.W.1) at 6 p.m.—Discussion on "The Influence of Infinitely Variable Torque Conversion on Engine Design".

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. W. Hechelhammer: "Polycarbonates—their Properties, Processing and Applications".

Society of Dyers and Colourists, London Section (joint meeting with the London Section of the Textile Institute, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Prof. J. B. Speakman: "To Blend or not to Blend—That is the Question".

Wednesday, January 7

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. Dr. J. M. van der Vlerk (Leyden): "Problems and Principles of Tertiary and Quaternary Stratigraphy" (Fourteenth William Smith Lecture).

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Miss V. R. Cane: "Behaviour Sequences as Semi-Markov Chains".

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. G. H. Clark and Mr. D. A. Davidson: "Petroleum-Based Launching Lubricants".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 7.45 p.m.—Dr. R. C. Sutcliffe, F.R.S.: "The Nature of Weather Forecasting" (Second Evening Discourse).

Thursday, January 8

Institution of Naval Architects (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 4.45 p.m.—Dr. J. C. Hudson, Mr. J. F. Stanners and Mr. A. G. B. Miller: "The Surface Preparation of Ship Plate (Outer Bottom Plating) for Painting".

Institute of Refrigeration (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Dr. G. G. Haselden: "An Economic Evaluation of Large Ammonia Absorption Refrigerating Machines".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. L. G. Brazier: First Hunter Memorial Lecture.

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Birdcage Walk, London, S.W.1), at 6 p.m.—Mr. R. Hafner: "The Tandem Rotor Helicopter".

Friday, January 9

Public Schools Appointments Bureau Conference (organized by the Plastics Institute, at the Borough Polytechnic, London, S.E.1), at 10.15 a.m.

Association of Applied Biologists (in the Meeting Room of the Royal Entomological Society, 41 Queen's Gate, London, S.W.7), at 10.50 a.m.—Symposium on "Insects and Public Health".

Institution of Electrical Engineers, Medical Electronics Discussion Group (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Physiologists' Requirements for D.C. Amplifiers" opened by Dr. M. H. Evans and Dr. G. B. B. Chaplin.

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. R. R. Arnold and Dr. P. W. Whitton: "Stress and Deformation Studies for Sandwich Rolling Hard Metals".

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. J. L. Ashworth, Mr. H. B. Mann and Dr. T. H. Morton: "Optical Brightening Agents in Action".

Saturday, January 10

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. W. Watson: "The Mizutori Ceremony of the Todaiji Temple in Nara: a Purification Ceremony After the New Year".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Chief Horticulturist (highly qualified, with an appropriate university degree, wide horticultural experience and preferably experience of tropical horticulture) in the Department of Research and Specialist Services, Ministry of Agriculture, Federation of Rhodesia and Nyasaland, to be responsible for advising on horticultural policy as well as formulating a suitable programme for horticultural research—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (January 17).

Assistant Lecturer, Grade A (male), at H.M. Dockyard Technical College, Singapore, to teach Mathematics and/or Science—The Director (Y), Education Department, Admiralty, London, S.W.1 (January 20).

Research Assistant (with a first- or good second-class degree in botany or zoology and training or research experience in cytology), to work on cytological effects of ionizing radiation in plants—Dr. G. R. Lane, Department of Botany, The University, Southampton (January 24).

Lecturer in Mathematics (Pure Mathematics) at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 27).

Lecturer in Chemistry, a Lecturer in Physical Chemistry, and Lecturers (2) in Geography at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 30).

Lecturers (2) in Zoology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 30).

Research Assistant (university graduate with research experience and with a knowledge of poultry husbandry) in Poultry Husbandry for duties which will involve the planning and execution of experiments concerned with husbandry problems, together with the interpretation of the results and the preparation of reports arising from the work—The Principal, Harper Adams Agricultural College, Newport, Shropshire (January 30).

Lecturer (honours science graduate, with experience in virology and in research methods) in Bacteriology—The Secretary, The University, Edinburgh (January 31).

Lecturer or Assistant in Statistics in St. Salvator's College, St. Andrews—Joint Clerk to the University Court, College Gate, St. Andrews (January 31).

Lecturer/Senior Lecturer in Agriculture (Biometrical Methods) and a Lecturer in Agronomy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

Lecturer (with a degree in electrical engineering and preferably experience in one or more of the fields of light current engineering) in Electrical Engineering at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

Senior Technician (preferably with good qualifications in histology) in the Department of Zoology, University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 31).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Engineering, Pharmacology, or Physics—The Secretary, The University, Aberdeen (February 13).

Imperial Chemical Industries Research Fellows in Physics, Chemistry, Biochemistry, Engineering, Metallurgy and Pharmacology or any related subjects—The Registrar, The University, Liverpool (February 14).

Lecturer (with experience in one of the following fields of research: (*a*) adsorption and heterogeneous catalysis; (*b*) use of radioisotopes; (*c*) gas chromatography) in Physical Chemistry—The Secretary, The Queen's University, Belfast (February 14).

Lecturer in Mechanical Engineering—The Secretary, The Queen's University, Belfast (February 20).

Professor of Anatomy at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

Research Fellow (Ph.D. standard) in the Department of Botany, to undertake research in the field of mycology and/or plant pathology—The Registrar, The University, Birmingham 15 (March 1).

Lecturer or Assistant Lecturer in Electronics—The Secretary and Registrar, The University, Southampton (March 14).

Lecturers or Assistant Lecturers (with experience in at least one of the following fields: generation, transmission and/or distribution of electrical power, measurements, electrical machinery) in Electrical Engineering—The Secretary, The Queen's University, Belfast (March 20).

Lecturer in Botany, a Lecturer in Zoology and a Lecturer in Biochemistry—The President, University College, P.O. Box 399, Addis Ababa, Ethiopia.

Physics Technician (preferably with a knowledge of electronics or vacuum technique), for work on a high voltage accelerator—The Administrative Officer, R.B.U. Medical Research Council, A.E.R.E., Harwell, Berks.

Scientific Assistant (Technician) (preferably with some experience of light engineering), to work on a project to develop special equipment for use in biological research and industry—Prof. O. L. Zangwill, Psychological Laboratory, The University, Downing Place, Cambridge.

TECHNICIAN (preferably with previous experience) FOR THE CHEMISTRY LABORATORIES—The Secretary, Royal Holloway College (University of London), Englefield Green, Surrey.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The British Railway Locomotive 1803–1853: a Brief Pictorial History of the First Fifty Years of the British Steam Railway Locomotive. Compiled by G. F. Westcott. Pp. 14+32 plates. (London: H.M. Stationery Office, 1958. Published for the Science Museum.) 3*s*. 6*d*. net. [2410

Department of Scientific and Industrial Research: Building Research Station. National Building Studies. Research Paper No. 20: Reactions Between Aggregates and Cement. Part 4: Alkali-Aggregate Interaction: The Expansion Bar Test and Its Application to the Examination of some British Aggregates for Possible Expansive Reaction with Portland Cements of High Alkali Content. By Dr. F. E. Jones and R. D. Tarleton. Pp. iv+43+8 plates. 4*s*. net. Research Paper No. 25: Reactions Between Aggregates and Cement. Part 5: Alkali-Aggregate Interaction: Effect on Bending Strength of Mortars and the Development of Gelatinous Reaction Products and Cracking. Part 6: Alkali-Aggregate Interaction: Experience with Some Forms of Rapid and Accelerated Tests for Alkali-Aggregate Reactivity—Recommended Test Procedures. By Dr. F. E. Jones and R. D. Tarleton. Pp. iv+64+4 plates. 4*s*. 6*d*. net. (London: H.M. Stationery Office, 1958.) [2410

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 685, Vol. 241 (23 October, 1958): Triangulate Monograptids from the *Monograptus gregarius* Zone (Lower Llandovery) of the Rheidol Gorge (Cardiganshire). By Margaret Sudbury. Pp. 485–555+plates 19–23. (London: Royal Society, 1958.) 30*s*. [2410

Water Research Association. Third Annual Report, 1957–58. Pp. 31+4 plates. (Redhill: Water Research Association, 1958.) [2710

Institute of Personnel Management. Annual Report 1957–58. Pp. 23. (London: Institute of Personnel Management, 1958.) [2710

The Use of the Hollerith Type 555 Electronic Calculator for Scientific Computation. By J. E. Hailstone. Pp. 38+appendix A and B. (London: Hollerith Group of Companies, British Tabulating Machine Co., Ltd., 1958.) [2710

Organic Chemical Reagents. Monograph No. 36: *p*-Bromomandelic Acid: Reagent for Zirconium. By E. J. Newman. Pp. 4. (Chadwell Heath: Hopkin and Williams, Ltd., 1958.) [3010

Department of Scientific and Industrial Research. Fuel Research 1957: Report of the Fuel Research Board with the Report of the Director of Fuel Research for 1957. Pp. iv+59+4 plates. (London: H.M. Stationery Office, 1958.) 4*s*. 6*d*. net. [3010

Air Ministry: Meteorological Office. Meteorological Reports, No. 20: Equivalent Headwinds at Heights of 30,000 feet and 40,000 feet along Air Routes (Supplemented and Revised). By P. Graystone. Pp. ii+35. (M.O. 621d.) (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [3010

Seventh Report from the Select Committee on Estimates together with the Minutes of the Further Evidence taken before Sub-Committee C and an Appendix, Session 1957–58—Nature Conservancy. Pp. ix+79. (London: H.M. Stationery Office, 1958.) 5*s*. net. [3010

Ministry of Agriculture, Fisheries and Food. Technical Bulletin No. 1: Specifications and Methods of Analysis for Certain Pesticides. Compiled at the Plant Pathology Laboratory of the Ministry of Agriculture, Fisheries and Food. Third Edition. Pp. x+126. (London: H.M. Stationery Office, 1958.) 7*s*. net. [3010

Ethylene Diamine Tetra-Acetic Acid: a Bibliography of Analytical Uses. Pp. ii+73. (Middleton, Manchester: The Geigy Company, Ltd., 1958.) [3010

International Association for the Exchange of Students for Technical Experience. Eleventh Annual Report, 1958. Pp. 71. (London: International Association for the Exchange of Students for Technical Experience, 1958.) [3010

City of Manchester Public Libraries. 106th Annual Report of the Libraries Committee 1957–1958. Pp. 24. (Manchester: The Public Libraries, 1958.) [311

Planning, Vol. 24, No. 427 (31 October, 1958): Prospects of Television. Pp. 225–256. (London: Political and Economic Planning, 1958.) 3*s*. 6*d*. [311

British Drug Houses, Ltd. Sugar Phosphates and some Closely Related Substances. Pp. 20. (Poole: British Drug Houses, Ltd., 1958.) [311

Institution of Chemical Engineers. Notes on Laboratories for the Teaching of Chemical Engineering. Pp. 11. (London: Institution of Chemical Engineers, 1958.) [311

Library of Medicinal Plants collected by Henry D. de Laszlo, M.A., Ph.D. Pp. iii+52. (Cambridge: W. Heffer and Sons, Ltd., 1958.) 10*s*. 6*d*. net. [311

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 122: Poultry Mites, Lice and Fleas. Pp. 8. (Belfast: Ministry of Agriculture, 1958.) [311

Bulletin of the British Conference on Automation and Computation, Vol. 1, No. 1 (September–October 1958). Pp. 20. Published bi-monthly. Subscription rate: 12*s*. per annum; single issues, 2*s*. (London: B.C.A.C. Bulletin, c/o The Institution of Mechanical Engineers, 1958.) [311

Agricultural Research Institute of Northern Ireland, Hillsborough, Co. Down. Thirty-first Annual Report, 1957–1958. Pp. 42. (Hillsborough, Co. Down: Agricultural Research Institute of Northern Ireland, 1958.) [311

Other Countries

Chicago Natural History Museum. Fieldiana: Botany. Vol. 24, Part 1: Flora of Guatemala. By Paul C. Standley and Julian A. Steyermark. Pp. ix+478 (121 figures). 8 dollars. Fieldiana: Geology. Vol. 10, No. 33: New Salamanders of the Family Sirenidae from the Cretaceous of North America. By Coleman J. Goin and Walter Auffenberg. Pp. 449–459. 45 cents. Fieldiana: Zoology. Vol. 39, No. 16: Descriptions of Abyssal Benthic Fishes from the Gulf of Mexico. By Marion Grey. Pp. 149–183. 75 cents. Vol. 39, No. 17: Streblidae from Yemen, with description of One Subspecies of *Ascodipteron* (Diptera). By B. Jobling. Vol. 39, No. 18: Egyptian Snakes of the Genus *Psammophis*. By Hymen Marx. Pp. 191–200. 30 cents. Vol. 39, No. 19: Some Rare or Little-known Mexican Coral Snakes. By Karl B. Schmidt. Pp. 201–212. 25 cents. (Chicago, Ill.: Chicago Natural History Museum, 1958.) [2710

Forty-first Annual Report of the National Research Council of Canada, 1957–1958, including the Annual Report of Canadian Patents and Development Limited. Pp. 54. (N.R.C. No. 4783.) (Ottawa: Queen's Printer, 1958.) [2710

Microwave Propagation in Snowy Districts. Edited by Prof. Y. Asami. (Monograph Series of the Research Institute of Applied Electricity, No. 6, 1958.) Pp. v+198. (Sapporo: Research Institute of Applied Electricity, Hokkaido University, 1958.) [2710

Department of Fisheries, Ceylon. Fisheries Research Station, Colombo. Bulletin No. 7: Mechanization of Fishing Craft and the Use of Improved Fishing Gear. By E. R. A. de Sylva. Pp. 24+1 map. Administration Report of the Director of Fisheries for 1957. Pp. 31. 80 cents. (Colombo: Government Publications Bureau, 1958.) [3010

Infra-red Absorption of the Carbon-Carbon Double Bond Stretching Vibration. By G. Dijkstra. (Academic Thesis for the examination for the degree of Doctor of Science in the University of Amsterdam.) Pp. 107. (Amsterdam: G. Dijkstra c/o The University, 1958.) [3010

Transactions of the National Institute of Sciences of India. Vol. 4, No. 1: The Petrography and Petrogenesis of Forty-eight Flows of Deccan Trap Penetrated by Borings in Western India. By Dr. W. D. West. Pp. 1–56+3 plates. (New Delhi: National Institute of Sciences of India, 1958.) Rs. 7.00. [3010

Chicago Natural History Museum. Fieldiana: Geology. Vol. 11, No. 9: Early Devonian Fishes from Utah, Part 3: Arthrodira. By Robert H. Denison. Pp. 461–551. 2.50 dollars. Fieldiana: Zoology. Vol. 36, No. 5: Birds of Volcán de Chiriqui, Panama. By Emmet R. Blake. Pp. 499–577. 1.50 dollars. Vol. 42, No. 3: Philippine Zoological Expedition, 1946–1947. A synopsis of Philippine Endomychidae (Coleoptera). By M. F. Strohecker. Pp. 19–48. 75 cents. Vol. 42. No. 4: Philippine Zoological Expedition, 1946–1947. Notes on Philippine Mallophafa, 1: Species from Ciconiiformes, Anseriformes, Falconiformes, Galliformes, Gruiformes and Charadriiformes. By K. C. Emerson and Ronald A. Ward. Pp. 49–61. 30 cents. Vol. 42, No. 5: Philippine Zoological Expedition 1946–1947. Stag Beetles (Coleoptera: Lucanidae). By Bernard Benesh. Pp. 63–75. 30 cents. (Chicago, Ill.: Chicago Natural History Museum, 1958.) [3010

Museum of Comparative Zoology at Harvard College. Breviora. No. 92 (September 17, 1958): A New Genus of Erethizontid Rodents from the Colhuehuapian of Patagonia. By Bryan Patterson. Pp. 4. No. 93 (September 18, 1958): A New Barylambdid Pantodont from the Late Paleocene. By Bryan Patterson and Elwyn L. Simons. Pp. 8. No. 94 (September 18, 1958): Affinities of the Patagonian Fossil Mammal Necrolestes. By Bryan Patterson. Pp. 14. No. 95 (September 19, 1958): A New Bolivian Land Snail of the Genus *Drymaeus*. By Juan Jose Parodiz. Pp. 3. No. 96 (September 19, 1958): A New Dichobunid Artiodactyl from the Uinta Eocene. By C. Lewis Gazin. Pp. 6. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [311

A Discussion of Short-Lived Solar Radio Transients at 200 Mc/s. By C. de Jager and F. Van 'T Veer. (Verlandelingen der Koninklijke Nederlandse Akademie van Wetenschappen, Afd. Natuurkunde, Eerste Reeks, Deel 21, No. 3.) Pp. 61. (Amsterdam N.V. Noord-Hollandsche Uitgevers Maatschappij, 1958.) [311

Smithsonian Institution: Astrophysical Observatory. Smithsonian Contributions to Astrophysics. Vol. 3, No. 1: The Regression of the Node of the Quadrantids. By Gerald S. Hawkins and Richard B. Southworth. Pp. ii+6. 15 cents. Vol. 3, No. 2: Catalogs of Meteor Radiants. By Gerald S. Hawkins. Pp. ii+7–8. 10 cents. (Washington, D.C.: Government Printing Office, 1958.) [311

World Health Organization. Technical Report Series, No. 151: Mental Health Aspects of the Peaceful Uses of Atomic Energy: Report of a Study Group. Pp. 53. (Geneva: World Health Organization, London: H.M. Stationery Office, 1958.) 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. [311

Metropolitan Life Assurance Company. Statistical Bulletin, Vol. 39 (September, 1958): Children Growing Taller. Health in Alaska. Longevity of Industrial Population in 1957. Decrease in Homicide Rate. Pp. 12. (New York: Metropolitan Life Assurance Company, 1958.) [311

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SCIENTIFIC MAN-POWER AND DEVELOPMENT IN BRITAIN

THE eleventh annual report of the Advisory Council on Scientific Policy*, for the period July 1, 1957–June 30, 1958, is concerned with some aspects of three main topics: the organization and administration of scientific research; scientific man-power; and various measures which affect the efficiency with which scientific man-power is used. With the magnitude of the research effort of Great Britain, to which a large part of the previous report was devoted, the present report is scarcely concerned, other than to supply in an appendix revised figures for Government expenditure on civil research. These put the total for 1958–59 at £28·5 million, compared with £26·6 million in 1956–57. For the Research Councils the figures are: Scientific and Industrial Research, £11·4 million and £10·5 million; Agricultural Research, £5·08 million and £4·6 million; Medical Research, £3·1 million and £2·8 million; Nature Conservancy, £350,000 and £305,000. The total scientific staff employed was 6,449 in 1958–59, compared with 6,139 in 1957–58. As regards the distribution of this effort in 1958–59, £8,289,000 is for agriculture, forestry, fisheries and food; £13,386,000 for industry and communications; £3,860,000 for medical research and health; £1,735,000 for overseas research; and £1,064,000 for the Government Chemist, meteorology, oceanography and observatories.

On the organization of research effort, the report this year deals solely with the financing of scientific research in British universities, and that topic, with the exception of two aspects which are related to the effective utilization of scientific man-power and are discussed below, has already been considered in these columns (see *Nature*, December 27, p. 1757). On scientific man-power the Advisory Council reports that a more comprehensive review of the membership of professional institutions has been possible, and on this basis it is estimated that some 13,000 professional scientists and engineers qualified for the first time in 1957. This estimate takes account of the number of engineers with multiple qualifications without a university degree among the 7,900 admitted to thirteen professional engineering institutions; about 200 of nearly 900 new members admitted to the Royal Institute of Chemistry and the Institute of Physics had no university degree.

Figures from the University Grants Committee indicate a 13 per cent increase in graduates in engineering in 1956–57, but only about 3 per cent in pure science; and if, as expected in framing the building plans of the universities, some two-thirds of the additional students read for degrees in pure science and technology, the student population in these departments will increase from 35,000 (October 1957) to about 55,000 by 1966, a figure which should give about 12,000 graduate scientists and engineers a year, compared with 7,800 in 1956–57. By that date, too, it is expected that the technical colleges will be supplying about 9,500 scientists and technologists of professional status, and this figure might rise to 10,500 a year by 1970 if the expansion continues in the late 1960's. This total figure of 22,500 thus leaves a reasonable margin over the target of 20,000 set in the report on "Scientific and Engineering Man-power in Great Britain" published in 1956; and the Advisory Council appears to be satisfied, from the rising number of those staying on at school until the age of seventeen and from current estimates of the probable intake into universities, technical colleges and teacher training colleges, that there should be no lack of young people of ability to fill the larger number of places in the universities and technical colleges.

This position, however, emphasizes the critical importance of an adequate supply of science and mathematics teachers for the schools, and while the Advisory Council recognizes frankly enough that the effectiveness of the expansion plans ultimately depends on this, its current report is no more reassuring on this point than the previous one. The main pressure in the next few years will fall on the maintained schools, which are already short of graduate teachers of science and mathematics and have difficulty in recruiting staff with satisfactory qualifications. The position seems likely to grow worse, even though schools and institutions of further education have increased their staffs by about 500 graduate teachers of science and mathematics a year during the past four years. In 1956–57 the net increase rose to about 845, with a further increase of 120 in graduate engineers teaching in technical colleges; but this total in a particularly favourable year is still 400 short of the average annual increase required to raise the number of these teachers in schools and technical colleges to 29,000 in 1959—the number estimated as needed at the time of the earlier survey of scientific and engineering man-power in Great Britain. Since then the Committee on Scientific Man-power has suggested that a further 4,000 teachers would be needed to maintain staffing ratios in view of the increase in pupils in secondary schools, while the Willis Jackson Committee has estimated that technical colleges in England and Wales need to increase their graduate teachers of science and technology by 250 and 265 a year, respectively, and also recommended an increase in provision for full-time training in technical teacher training colleges from 300 to 500.

This shortage of science and mathematics teachers is only one aspect of a general shortage of teachers, and the Advisory Council welcomes the recent statement by the Minister of Education that within the programme to provide 12,000 new places in teacher training colleges in England and Wales by the autumn of 1962, special measures will be taken to train extra teachers of science and mathematics. No proposals, however, for specifically closing the gap have been forthcoming, nor are any advanced by the

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* Annual Report of the Advisory Council on Scientific Policy, 1957–58. Cmnd. 597. Pp. 22. (London: H.M. Stationery Office, 1958.) 1*s*. 3*d*. net.

Advisory Council, and the shortage seems likely to continue. It is ignored in the latest White Papers dealing with secondary education. Rightly, the Council points out that it is the teachers now at work who bear the brunt of the pressure on the secondary schools. The increase in the output of scientists and engineers from the universities should ultimately increase the number of such graduates who take up teaching, and the introduction of more degree courses suitable for those intending to teach could also help; but neither measure meets the immediate emergency.

In these circumstances, the Advisory Council directs attention to the importance of measures which can ease the task of the science and mathematics teachers. The provision of more accommodation and the rapid modernization of laboratory and equipment are one way; the provision of laboratory assistance is another. There is indeed a continuing need for schools and colleges to show ingenuity in making the most of existing staff and facilities, but the task should not be left to them alone. At this juncture a generous policy in such matters would pay the nation most handsome dividends, and might well prove decisive in narrowing the critical gap. It should be urged on the Government and on educational authorities with all the emphasis and authority at the command of the Advisory Council and others who understand the importance of a sufficient supply of scientific and technical man-power.

The major importance of the Advisory Council's present report lies indeed in its comments on several of these factors which determine the effective use of existing supplies of scientific and technical man-power. In its previous report, it pointed out that the effectiveness of university research would be much enhanced by the comparatively small expenditure necessary to increase substantially the number of supporting staff in university laboratories. In the present report it returns to the problem at greater length.

In general, the responsibility for providing technicians rests, and must continue to rest, with the universities. The Research Councils may indeed finance the employment of specialist technicians if a university department, in applying for a piece of expensive and complicated equipment, can show that a specially qualified technician is also needed and cannot be recruited without financial assistance. University departments, however, have the utmost difficulty in obtaining technicians, and particularly in recruiting high-grade men with specialist qualifications. The Committee of Vice-Chancellors and Principals has now arranged an investigation into the work, qualifications and conditions of employment of technicians in university departments as compared with those of technicians outside the university field. Reiterating the conclusion of its previous report as to the large return to be reaped from comparatively small expenditure in this way, the Advisory Council stresses the futility of encouraging scientists to enter university research and then to deny them the kind of technical assistance which they would enjoy in Government or industrial research establishments. The private foundations have frequently given some assistance here, but the problem is primarily one for the universities themselves, and the Advisory Council is not alone in hoping that university authorities will, as a matter of urgency, consider how they can increase the supply of technicians available to their scientific and technological departments.

Related to this is the question of equipment. All the Research Councils make grants to meet the cost of special equipment required for the research projects which they are supporting; but present practice in the matter of more general research equipment is not uniform. The Advisory Council recognizes that it is more in accordance with university autonomy for the universities to finance the purchase of equipment themselves; but it also recognizes the need for special arrangements, including additional sources of finance, for certain kinds of expensive research equipment needed to-day in science and technology. Indeed, apart from the question of availability of finance, university departments may well be reluctant to embark on the installation of such equipment, because of the danger of distortion of effort and the difficulty of disengagement with change of staff.

Such reasons, and the further difficulty of ensuring that economic use is made of such equipment, have led to suggestions that it is best installed at independent research institutions; but that course involves removing important fields of research from university departments. The National Institute for Research in Nuclear Science is one attempt to meet this difficulty. As the Advisory Council on Scientific Policy points out, this provides, for common use, equipment which is beyond the scope of individual universities and institutions to provide for themselves. It has also been decided that the University Grants Committee should be responsible for grants for the purchase of electronic computers; but no special arrangements for providing through the University Grants Committee the various types of apparatus costing £2,000–£10,000 which are necessary in many fields to-day and which many university departments cannot purchase from their annual allocations of general-purpose funds.

Nor is this all. Modern equipment for general research purposes, besides increasing the effectiveness of research and the rate at which it can be carried out, adds greatly to the efficiency with which both scientists and technicians can be used. Accordingly, out-of-date equipment in our universities, when used for research as distinct from teaching, represents a drain on valuable man-power which is completely uneconomic and unrealistic. Add to this the continuing trend of equipment to increase in complexity and cost, and the delay which is often involved before newly developed or improved equipment, too expensive to be charged to the annual budget, can be obtained for general research purposes, and it is obvious that the Advisory Council is directing attention to a problem which offers considerable possibilities of a saving in man-power.

The University Grants Committee and the Research Councils are agreed that the former is not best fitted to deal with such specialized requests, and that it would be preferable for them to be considered by the appropriate Research Council or by the Government grant boards of the Royal Society. During the past two years, the Department of Scientific and Industrial Research has invited applications for grants to finance the purchase of expensive equipment, not only for particular research projects receiving its support, but also to facilitate progress in wider fields of research within the Council's general sphere of interest. The other Councils are willing to make similar arrangements, provided they receive sufficient funds for the purpose; and the Advisory Council on Scientific Policy hopes that by next year they will be in a position to invite requests for specific types of equipment required for research but unrelated to particular research projects. Furthermore, it recommends that the procedure and the scale of expenditure should be reviewed by the University Grants Committee and the Research Councils before the universities are asked to frame the proposals for the next quinquennium.

This, however, is only the beginning. It is not sufficient to ascertain the potential demand for such equipment or even for adequate funds for the purpose to be placed at the disposal of the Research Councils. It is no less important that the procedure should be flexible and swift in action, so that there is no undue delay in meeting an established and approved need. Here the question of Treasury control requires some forethought, and it is to be hoped that, in framing the proposals for administering grants for this purpose, due weight will be given to the evidence submitted recently to the Select Committee on Estimates relating to Treasury control of expenditure and to the Department of Scientific and Industrial Research.

A number of miscellaneous activities considered by the Advisory Council also bear on this question of making the fullest possible use of existing scientific and technical man-power in Britain, in the universities and elsewhere. The United Kingdom is participating in several projects of the Governing Committee for Scientific and Technical Personnel established in June 1958 by the Council of the Organization for European Economic Co-operation. These projects include an annual review of action taken in member countries to increase the supply of scientific and technical man-power; vacation courses for science teachers; and fellowships to enable senior lecturers or research workers to make short visits to research or training institutions in other countries. They should yield a considerable direct return for the United Kingdom's contribution of £15,000.

Again, the United Kingdom representative on the Science Committee of the North Atlantic Treaty Organization, which the North Atlantic Council decided on December 1957 to establish, is the deputy-chairman of the Advisory Council on Scientific Policy, Sir Solly Zuckerman. Apart from its consideration of problems in the field of defence science, this Committee has already considered a proposal to establish a substantial number of N.A.T.O. fellowships to be held by postgraduate students, primarily for study abroad, and also proposals for financial support for advanced study institutes for special subjects. The Council believes that this Science Committee can carry out a valuable function by stimulating and encouraging the activities of existing organizations in this field and by carrying out certain projects which are not being undertaken by other bodies. The Council's Committee on Overseas Scientific Relations has also reviewed the present organization and activities of the scientific missions attached to certain United Kingdom embassies, and the report enters a strong plea in support of the scientific attaché.

A review of the work of missions and attachés in recent years has convinced the Council that the outlay in money and personnel has been fully justified. Men with the combination of personal and scientific qualities necessary to make a first-class scientific attaché are relatively rare; but they perform a function which visiting specialists of international reputation in a particular field cannot fill, because they cannot give the continuity essential for the attaché's work. Much of an attaché's work is unspectacular but none the less valuable. The Advisory Council considers that the territory covered by one attaché is sometimes too large, and it also urges that appointments should not be limited to countries having a high current level of technical development.

While the Advisory Council fully recognizes that the resources of Britain are limited, its lead is unequivocable, though it might have argued more clearly the economic advantages of extending the system to other countries. Although the Council is clearly convinced of the advantages of more co-operation between the Western nations in scientific and technological research, and has re-constituted its Committee on Overseas Scientific Relations, it is by example rather than specific recommendation that the lead is given. Thus it welcomes the Government announcement that negotiations are proceeding with the London County Council for the lease of a site on the South Bank site to house a new building to accommodate the Patent Office and a new National Reference Library of Science and Invention built up from the existing Patent Office Library. The Advisory Council welcomes this somewhat belated decision, but it seems content to accept the delay of possibly five years before building even commences. No mention is made of the cost to the nation of this further delay and its implications.

There will, of course, always be differences of opinion as to the relative importance of particular proposals; but the Advisory Council on Scientific Policy has certainly directed attention to a varied range of issues which bear on the development in Britain of scientific and technical man-power. A programme of action and exposition is set forth clearly enough, to be pursued by those who appreciate the bearing on the future of Britain of the effective utilization of existing scientific and technical resources, and the need for early expansion of the supply of scientists, technologists and supporting technicians.

ANTHROPOLOGICAL STUDIES

Method in Social Anthropology

Selected Essays. By A. R. Radcliffe-Brown. Edited by Prof. M. N. Srinivas. Pp. xxi+189. (Chicago: University of Chicago Press; London: Cambridge University Press, 1958.) 28*s*. net.

The Scope of Physical Anthropology and Its Place in Academic Studies

A Symposium held at the Ciba Foundation, 6th November 1957. Edited by D. F. Roberts and J. S. Weiner. Pp. vii+66. (New York: The Wenner-Gren Foundation for Anthropological Research. Published for The Society for the Study of Human Biology, 1958. Obtainable from the Institute of Biology, 41 Queen's Gate, London, S.W.7.) n.p.

THE first part of this work of the late Prof. A. R. Radcliffe-Brown includes a number of his previously published essays in chronological order. These are concerned principally with the scope of social anthropology and its relation to other disciplines, mainly psychology and history. In the latter regard Radcliffe-Brown was at considerable pains to show that the problems of anthropology are quite different from those of ethnology. Social anthropology must also employ comparative methods, but with the aim of exploring varieties of social life as a basis for the theoretical study of human phenomena rather than of discovering historical connexions between peoples. It seeks not to 'explain', but to understand a particular feature of a particular society by first seeing it as a particular instance of a general kind of social phenomena, and then by relating it to a certain general tendency in human societies. Radcliffe-Brown returned to the comparative method in the first five chapters of an introductory work which was uncompleted at his death. These chapters, which are included in the present book, provide a very clear, if somewhat abbreviated, exposition of his scientific approach and employment of such central concepts as 'social structure', 'social organization', 'social evolution', etc. "R.-B.'s" many admirers and followers will be glad to have these posthumous essays and selection of writings within a single volume, although its actual title is slightly misleading. His main contribution to methodology is to be found elsewhere—in his "Structure and Function in Primitive Society" and in his "Introduction to African Systems of Kinship and Marriage".

The second of the volumes under review comprises some ten papers, read at a symposium in 1957 at the Ciba Foundation, with the object of defining the scope of physical anthropology and introducing it to those in cognate sciences. Sir Wilfrid Le Gros Clark, who opened the session, feels that physical anthropology is a historical subject in so far as it studies the organic relation of the human species to lower animals, its evolutionary origin, its differentiation into races and sub-races, and the relation of physique to different conditions of life in the past. He considers, however, that future research will be mainly directed to the study of living populations, particularly in regard to problems of human genetics. An investigation of the latter kind is described by A. C. Stevenson, who summarizes the results of an examination of population genetics in Northern Ireland. Experimental work is also the subject of A. E. Mourant and of N. A. Barnicot, the former being concerned primarily with organization for research in serology and the latter mainly with laboratory techniques in the study of living populations. Kenneth P. Oakley describes physical anthropology in the British Museum, and J. M. Tanner discusses the place of human biology in medical education. J. S. Weiner's contribution is devoted to the same topic. He points out that there is a dearth of teaching in human genetics and considers that this ought to be remedied in the universities. Physical anthropology could be taught at an elementary level as an educational or 'liberal' discipline as well as at an advanced level as a specialized professional subject. Prof. J. Z. Young also makes a somewhat similar point, arguing that human biology can help medical students over the boundaries between physical science and the cultural sciences. L. S. Penrose contributes a short paper about human variability and adaptability, and Sir Solly Zuckerman sums up.

KENNETH LITTLE

TECHNOLOGY OF THE INDUSTRIAL REVOLUTION

A History of Technology

Edited by Charles Singer, E. J. Holmyard, A. R. Hall and Trevor I. Williams. Assisted by Y. Peel, J. R. Petty and M. Reeve. Vol. 4: The Industrial Revolution, *c*. 1750 to *c*. 1850. Pp. xxxiii+728+48 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 168*s*. net.

WHEREAS each of the first two volumes of this great history holds some thousands of years between its covers, and the third about two hundred and fifty, this fourth volume covers only a hundred—from 1750 to 1850, the period of the Industrial Revolution. But what a hundred years! Although the Renaissance and the invention of printing had brought a liberation of men's minds, their daily way of life remained little changed from the days of the Roman emperors. Their clothes were still woven on hand looms, they still struck fire from flint, still travelled by sail and horseback and still battered each other to death with axe and sword. The changes which began in the middle of the eighteenth century well merit the word 'revolution' and it was happy for England that her revolution took this form and belonged particularly to her.

The first chapters of the book are devoted to farming (by O. Beaumont, J. W. Y. Higgs and G. E. Fussell) and they are followed by an unexpected chapter on fish preservation (with a note on whaling), covering its entire history. After chapters on mining and the extraction of metals (the first extending up to 1875, for occasionally the articles rightly over-run the Industrial Revolution), the dominant subject of power is dealt with in three masterly essays. Prof. R. J. Forbes writes on the general development of motive power up to 1850, the late Dr. H. W. Dickinson deals specifically with the steam engine (a miracle of condensation, in both senses) and his successor at the Science Museum, A. Stowers, gives a concise history of waterwheels from 1500 up to 1850, referring much to the work of John Smeaton, "who could not touch anything without improving it" and whose name occurs *passim* throughout this volume.

Having established the basic elements of the Industrial Revolution—power and the metals—the development of the manufactures comes under discussion. It would have been impossible to describe all the by-ways of industrial chemistry in such a work as this, so Dr. E. J. Holmyard writes on the progress of chemical theory and practice, while A. and N. L. Clow give a survey of the chemical industry and the way in which it interacted with the Industrial Revolution. The Clows also describe the growth of the pottery industry and wisely illustrate (among the plates) the beautiful ware of which they write.

Gas for lighting and heating is so much a British industry that Sir Arthur Elton's emphasis on the pioneer work on wood-distillation of Philippe Lebon is timely. Nevertheless, it seems a little over-stressed when compared with the practical results with coal of William Murdoch (his name is better spelt thus: the 'k' was merely a sop to the pronunciation of Southerners). Textiles (by Julia Mann and W. English) naturally have long articles, which are purely technical and do not deal with the growth of the 'factory system' and the attendant changes in the people's life—this is not a social history.

Machine tools, the handmaidens of the Industrial Revolution, are split into two sections, and one of the few foreign contributors, Maurice Daumas, of the Conservatoire National des Arts et Métiers, leads off with the largely French work in the field of precision mechanics used in making clocks and instruments. He unwittingly reveals the answer to a famous vexed question among gas-engineers—why the general public insists on calling 'gas-holders' by the familiar term 'gasometers'. It is because Lavoisier did so in his laboratory some twenty years before coal-gas was manufactured. K. R. Gilbert adds a definitive chapter on the machine tools of the engineer (containing the morbidly ambiguous note, "Clement built planer, manufactured taps and dies").

Dr. S. B. Hamilton, on building and civil engineering construction (the longest single contribution), describes the development of structural theory during the period (the era of cast and wrought iron) and links it with the great achievement of the new race of 'civil engineers'. Prof. Forbes's second article, on roads, takes us up to 1900, and it is sad to think that a hundred years have elapsed since Telford and McAdam (whose name is so often mis-spelt in other books) put Great Britain ahead of the world in this craft and we have been losing our position as road-builders ever since.

The chapter on ship-building is extraordinary, for it is devoted almost entirely to sailing ships. The use of steam is dismissed in a paragraph; yet the technique of marine engine building was founded and developed during the period in question, and the work of John Penn and of the firm of Maudslay, Sons and Field, among others, seems worthy of inclusion. This and railway engineering (which is entirely overlooked in this volume) are startling omissions from a book dealing with the technology of the Industrial Revolution.

This was not the era of electricity, but it gains an important place in the chapter on telegraphy by G. R. M. Garratt, and to complete the survey, there are good articles on glass, canals, sanitary engineering, cartography (another unexpected choice) and dredging.

Finally, there is an interesting, but rather diffuse, chapter by Prof. A. R. J. P. Ubbelohde summing up the change of technology from a 'craft mystery' to an exact science. This covers the whole period of the preceding volumes also, and deals with, among other things, the foundation and contributions to technological progress of the Royal Society, the French Encyclopædists and the British Association for the Advancement of Science. A tribute to the École des Ponts et Chaussées would have been appropriate here for, more than any other body, it gave the lead to civil engineering, and, as Dr. Hamilton shows in his article, produced some of the greatest constructional engineers and theorists of the period.

Much of the delight which this volume gives is due (as with the others) to the beautiful line drawings of D. E. Woodall, which embellish nearly every page. It would be carping to point out errors—inevitable in a work of this magnitude—but one cannot overlook the misattribution (to Telford) of Burdon's iron bridge over the River Wear, on Plate 29. As with all books cast in this mould, at first one is stunned by its apparent comprehensiveness; but on a second reading one becomes conscious of omissions (mostly caused by the limitations of space) and one yearns for a more detailed treatment of the various subjects. If an enterprising publisher were to invite each of the many contributors to re-write his chapter and expand it to the length of a book (with the same fine typography and drawings of this series), there would be created thereby a library of the technological achievements of the Industrial Revolution which would remain the standard reference for very many years.

G. B. L. Wilson

OCCULT VIRUSES

Symposium on Latency and Masking in Viral and Rickettsial Infections

The Proceedings of a Conference held at the University of Wisconsin Medical School, September 4, 5 and 6, 1957. Edited by Duard L. Walker, Robert P. Hanson and Alfred S. Evans. Pp. xi+202. (Minneapolis, Minn.: Burgess Publishing Company, 1958.) 4.75 dollars.

At one time when a virus was harboured by an organism, be it plant or animal, without apparent signs of its presence, it was thought sufficient to speak of it as a 'latent' virus. With the advance of knowledge, however, it became clear that there was more than one form of latency, and various expressions came into use to describe the phenomenon, not all of which were used with the same meaning by different authors. These expressions included such terms as 'symptomless', 'sub-clinical', 'inapparent' or 'latent'. Furthermore, as it became clear that in some cases the lack of overt symptoms depended on changes in the virus itself and not on the host, the situation became still more confused. For example, a 'masked virus' has been defined by Shope as one which is not itself directly demonstrable but is known to be present by circumstantial evidence. For some virologists, however, 'masked' sometimes means 'not infective', for others 'not detectable'. For many plant virologists masking could either mean that the lack of symptoms was a permanent natural phenomenon or that it could be brought about temporarily by changes in the environment.

In 1957, a conference attended by many leading virologists was held at the University of Wisconsin Medical School, first to discuss the underlying mechanism of virus latency and secondly to try to reach some agreement on the nomenclature and meaning of particular terms. The results of this conference have now been published and the book is dedicated to the late Dr. Francisco Duran-Reynals for his staunch advocation of the role of latent viral infection in the etiology of cancer.

So far as the nomenclature of latency was concerned, agreement was finally reached on a number of definitions. The term 'inapparent infection' was suggested to cover the whole field of virus infections which give no overt sign of their presence. The expression 'latent virus' is no more, and its place is taken by 'latent infection', which is 'inapparent infection' in a chronic condition where a certain host – virus equilibrium has been established. The use of the word 'masked' is discontinued and 'occult virus' is substituted to describe the cases where virus particles cannot be detected and in which the actual state of the virus cannot as yet be ascertained. 'Occult' viruses do not appear to fulfil Lwoff's precept: "in order that an infection, whether apparent or not, should be recognized as viral, infectious particles have to be detected and identified as a virus".

For viruses which have been shown to have developmental stages, the terms 'provirus', 'vegetative virus' and 'infective virus' are suggested.

As regards latency at the virus – cell level, a 'moderate' virus is one growing in a cell while still permitting its continued survival, a 'cytocidal' one kills the cell, and 'sub-moderate' covers intermediate cases.

While these definitions may not be acceptable to all virologists, the conference has served a most useful purpose in paving the way to a more stable nomenclature of the subject. The discussions on the underlying causes of latency are stimulating and may help to throw some light on this fascinating partnership between virus and cell.

KENNETH M. SMITH

THE TECHNOLOGY OF TRANSISTORS

Transistor Technology

(Bell Telephone Laboratories Series.) By Members of the Technical Staff of Bell Telephone Laboratories. Vol. 1. Edited by H. E. Bridgers, J. H. Scaff, and J. N. Shive. Pp. xxxvii+661. 131*s.* 6*d.* Vol. 2. Edited by F. J. Biondi. Pp. xiii+701. 131*s.* 6*d.* (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.)

THE ten years of intensive research which have followed the discovery of transistor action have been very fruitful. The two key materials, germanium and silicon, are now widely prepared with a purity and crystalline perfection unsurpassed for any substance; their bulk and surface properties have been exhaustively examined and the results have enabled theoretical advances to be substantiated. The properties of transistors have been explained very fully in physical terms and suitably expressed for use by electrical engineers. Metallurgical, physical and electrolytic methods of preparing transistors—with their key dimension, base-width, controlled to a micron or so—have led to production-lines the combined output of which now exceeds a million transistors a week. The impact on electronic equipment is beginning to be felt. But while the scientific, technical and review publications have devoted increasing space to all sides of the subject, the more advanced text-books have concentrated much more on analysing and applying the electrical properties of transistors than they have on describing methods of preparing the semiconductors and the many practical junction structures.

The Bell Telephone Laboratories played a major part throughout these ten years, for they followed up their original discovery with the first junction transistor, the first measurements of drift mobility and lifetime of minority carriers, zone refining and zone levelling, grown and diffused structures, the solar battery and other advances. There was much to look forward to, therefore, when it was announced that three volumes in the Bell Telephone Laboratories series of text-books were to be entitled "Transistor Technology". But 'technology' has no precise meaning; the Concise Oxford English Dictionary gives "the science of the industrial arts", a definition which, it might be argued, includes only those parts of a subject which have been based on empiricism. A wider meaning is applied here, however, particularly to Vol. 2, much of which is devoted to the analysis or prediction of the behaviour of the conventional three-terminal, three-layer transistor, of tetrodes and unipolar transistors, and of two- and four-layer diodes.

Vol. 1 is primarily a history of the developments made before April 1952, until when the Laboratories had had almost a monopoly of the main advances; in that month they disclosed their processes and design procedures to prospective licensees. What was then prepared is now published, with a little, but scarcely enough, revision in the light of later developments. The many comparative newcomers to the subject should read it, at least once. It does not demand much concentration, but it does convey something of the early atmosphere, when the subject was spreading so rapidly into several different fields of science. Some parts retain much of their importance, for example the preparation of germanium and the measurement of its key properties, while others, for example the fabrication of point transistors, have lost theirs.

Vol. 2 deals with some of the progress since 1952; it is essentially the reprinting of many papers, mostly by authors from the Laboratories. The introductory remarks to the different headings, under which the papers are grouped, are generally too short to weld the collection together and are uncritical. The opening chapter, a fairly recent review of the technology of silicon, with 156 references, moves at such a high speed that few points receive detailed description; but it is followed by good accounts of floating-zone refinement and zone levelling. The lengthy chapters which come next, on the design of diodes and triodes, contain many analyses of behaviour and include well-known papers by Ebers and Moll, Kingston, Moll and Ross, Pritchard, and Webster. Descriptions of a field-effect transistor and the solar battery follow; and the book concludes with a group of papers on those surface effects which have assumed importance in their own right and on which may well depend the reliability of transistors and hence the practicability of some large equipments now under development, each incorporating 10,000–30,000 transistors.

Only an interim assessment can be made of this large venture pending consideration of Vol. 3. But two points can be made already. The disjointed structure of Vol. 2 comes as a disappointment; and the undue length of some sections of Vol. 1, and the availability of almost all of Vol. 2 in well-known periodicals, promotes a sense of redundancy. The gap in text-book coverage may not be closed, despite the resources mustered.

J. R. TILLMAN

Ptaki Ziem Polskich

Tom II. By Jan Sokolowski. Pp. 569 (66 plates). (Warszawa: Państwowe Wydawnictwo Naukowe, 1958.) Cena zl. 85.

IN this second volume of "The Birds of Poland", Sokolowski deals with the Striges, Accipitres, Columbae, Pterocletes, Galli, Gressores, Phoenicopteri, Grues, Otides, Ralli, Laro-Limicolae, Lamellirostres (Anseres), Steganopodes, Tubinares, Podicipedes, Colymbi and Alcae, that reside in, migrate through, or visit Poland. He follows the same classification as in Vol. 1, which was reviewed in *Nature*, 182, 972 (1958).

The wealth of interesting information and acute observation collected in this volume is of great value to the ornithologist and the nature lover, but, as in Vol. 1, the generalized and organized treatment of the data is sadly missing. At least one of the author's remarks cannot remain unchallenged. He states that birds which soar do so only by thermal lift and only between 10 a.m. and 4 p.m. (pp. 42 and 182), but ignores the three other known sources of lift which are also used by birds in soaring flight: (*a*) the orographic lift during windy days over hilly country, which occurs at all times of day and under all conditions of cloud cover; (*b*) the wave-lift that occurs even under a complete cover of lenticular alto-stratus which enables birds such as vultures and kites to hang in the sky on the crest of the wave, for hours at a time; (*c*) the dynamic lift at all hours of the day and under all conditions of cloud cover utilized by those experts in soaring, the gull and the albatross, which sweep over the water using the wind-gradient and the up-currents created by the air blowing over the waves.

As in the first volume, the text is well illustrated with black-and-white drawings, but the numerous half-tone plates are badly reproduced from well-chosen photographs. It is regrettable that no scale is given in the colour plates, which are well drawn but poorly produced. The glossaries are very useful but contain some errors in spelling.

B. NOWOSIELSKI-SLEPOWRON

The Succession of Life through Geological Time

By Kenneth P. Oakley and Helen M. Muir-Wood. Third and revised edition. Pp. vii+94 (12 plates). (London: British Museum (Natural History), 1956.) 4*s*.

Fossil Amphibians and Reptiles

By W. E. Swinton. Second edition. Pp. ix+118+17 plates. (London: British Museum (Natural History), 1958.) 5*s*.

Fossil Birds

By W. E. Swinton. Pp. vi+63+11 plates. (London: British Museum (Natural History), 1958.) 5*s*. net.

ORIGINALLY prepared as a guide to an exhibit in the Department of Palæontology of the British Museum (Natural History) in London "The Succession of Life through Geological Time" has now appeared as a third edition. Its merits may be judged by the fact that it has achieved the independent status of a junior text-book in schools and universities in many parts of the world. In the new edition the text has been brought up to date and all the plates of vertebrate restorations have been replaced by original designs. Another well-known guide, Dr. W. E. Swinton's "Fossil Amphibians and Reptiles", has also appeared in a new edition. This handbook aims at giving a conspectus of the subject which can be used by the visitor in the galleries and also perused at leisure afterwards. It includes sufficient detail to be of value to the advanced student as well as the general reader. Based on the rich series of fossils in the Department of Geology of the Museum, it refers, where necessary, to material in other museums, and also directs attention to gaps in the national collection. The appearance of this handbook has been followed by another prepared by Dr. Swinton, "Fossil Birds". Its plan is similar to that of "Fossil Amphibians and Reptiles". Unlike amphibians and reptiles, however, which bulk largely in the fossil record yet are of slight importance in the living fauna of Britain, birds form an outstanding feature of the living fauna all the world over, but are only an insignificant element in the later geological formations. Nevertheless, these remains, which are well represented in the Museum collection, include many of first-rate interest and importance, of which *Archæopteryx*, the first known bird, is *facile princeps*; the original specimen of this famous 'missing link' is one of the Museum's greatest treasures. All three volumes are distinguished by some original designs by Maurice Wilson; they contribute greatly to publications of which the Museum staff may well be proud.

Feedback Control Systems

By Prof. Otto J. M. Smith. (McGraw-Hill Series in Control Systems Engineering.) Pp. xviii+694. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 101*s*. 6*d*.

A WIDE range of linear and non-linear control systems are considered here, and methods described for the analysis and design of these various systems. The book is arranged simply, having four parts. In Parts 1 and 2 the author deals with the analysis and synthesis of linear systems. Linear techniques include descriptions of the use of s-plane plots, root locus constructions, the G-plane (Nyquist) polar plot, Bode diagram, Routh's criterion, and impulse response calculation from the poles and zeros on the s-plane. Techniques are presented for analysis of linear systems with random input signals, and for their optimum design on the basis of minimum error power. The behaviour of systems containing a time-delay in the closed loop is considered, and the 'Posicast' control (a form of linear predictor control) of such systems is described.

Parts 3 and 4 present techniques for non-linear systems. Much of the analysis is concerned with relay systems, using phase plane and describing function methods. Unilateral and bilateral non-linearities are also considered, where saturation, hysteresis, and backlash are included among the examples taken. Synthesis of non-linear systems employing predictor control is dealt with in some detail, it being assumed here that the system is of the saturating type. The final chapter describes the fundamentals of carrier type control systems.

In general, the theory is adequately supported by worked examples, of which the chapters on non-linear systems are in fact almost entirely composed. Part 3, which purports to deal with the analysis of non-linear systems, would have benefited if a complete account of relevant techniques had been given, to include omissions such as non-linear systems with random inputs, and sampling systems. In common with many modern books on the subject, too much emphasis is placed on detailed analysis, and too little on the simple basic generalities. There is, however, very much to recommend the book to final-year and postgraduate students, especially in regard to relay systems and predictor control. M. J. SOMERVILLE

CARBON MONOXIDE CONTENT OF THE BLOOD AND OTHER OBSERVATIONS ON WEDDELL SEALS

By Dr. L. G. C. E. PUGH
Division of Human Physiology, National Institute for Medical Research, London

During a recent study of blood carbon monoxide levels in men living at Scott Base, Antarctica, it was found by chance that the blood of a Weddell seal contained as much carbon monoxide as the blood of men who are heavy smokers. As this finding appeared to be of some theoretical importance, further samples were collected and analysed for carbon monoxide.

Blood samples were obtained from seals which were being slaughtered to provide dog food. The animals were either shot or killed by a blow on the head with an ice-axe; blood was collected immediately from the neck vessel, or, in some cases, from the wound itself. The anticoagulant used was heparin. The bottles containing the blood were carried in the pocket to prevent freezing. The samples were analysed on the same day, using the special method of Scholander and Roughton[1] for small quantities of carbon monoxide. Determinations of carbon monoxide on human non-smokers were carried out by the same method on samples of venous blood. Acid-base and electrolyte determinations were made in Christchurch, New Zealand, on a specimen of plasma brought back to New Zealand in the frozen state. The seal from which the specimen was obtained was a large female which was killed with an ice-axe as it lay asleep on the ice near Scott Base. The animal did not breathe again after the blow on the head, but the heart went on beating for about 30 min. The point of the ice-axe penetrated the brain near the mid-line, causing profuse pulsatile hæmorrhage. Two 50-ml. nylon centrifuge tubes were filled with blood and closed with metal caps without trapping air. The samples were centrifuged within $\frac{1}{2}$ hr. and the plasma transferred to a specimen bottle under oil. The bottle was filled completely, and the screw cap replaced without trapping air bubbles. It was then placed out of doors to freeze. Plasma bilirubin was determined in London on a specimen from another animal. In neither of these samples was there any visible hæmolysis.

The results are shown in Tables 1–4.

It can be seen from Table 1 that the carbon monoxide content of blood samples taken from Weddell seals was on the average six times as high as the mean value for human non-smokers. The results are, in fact, comparable with the range of values usually found in persons who are heavy smokers, which is 0·5–1·5 per cent[2,3]. The oxygen capacity and hæmatocrit values were higher and the red-cell counts lower than normal values for man, implying larger red cells containing more hæmoglobin (Table 3). The large size of the red cells was confirmed by microscopic examination of blood films; although no measurements were made, the red cells of blood from Weddell seals were judged to be 9–10μ in diameter, a value of 7μ being assumed for the human red cells with which comparison was made. The oxygen capacity and hæmatocrit results were similar to values reported on related species of seal[5–7]. The red cell counts, on the other hand, were lower than the results of Harrison and Tomlinson[5] on *Phoca vitulina* pups (4·7–8·5 million per cu. mm.) and *Halichoerus grypus* (5·8 million per cu. mm.), which suggests that the red cells in the Weddell seal are larger than in related species.

The plasma electrolyte values of seal No. 6 of Table 1 are shown in Table 4. The results are similar to the normal values for man, except for the high potassium value, which is unexplained. A specimen of urine from the same seal was analysed with the following results: specific gravity, 1·035; urea, 2·5 gm. per cent; sodium, 138 m.equiv./l.; potassium, 47 m.equiv./l. The bilirubin concentration of a specimen of plasma from seal No. 4 was 1·5 mgm. per cent, which may be compared with the normal human range of 0·3–0·7 mgm. per cent by the same method.

It has been known for some years that small quantities of carbon monoxide are present in human blood, even in persons who neither smoke nor have been exposed to any other source of carbon monoxide[8,9]. A series of papers by Sjöstrand[9,10] has provided convincing evidence that carbon monoxide is formed in the body during the breakdown of hæmoglobin to bile pigments, and is excreted quantitatively via the lungs, the hypothesis being that one molecule of carbon monoxide is liberated when each of the porphyrin rings in the hæmoglobin molecule splits. Under certain conditions carbon

Table 1. The Carbon Monoxide Content of the Blood of Weddell Seals and Human Non-smokers

Index No.	Date	Blood carbon monoxide (vols. per cent S.T.P.)
	Weddell seals	
1	11.2.58	0·60, 0·63
2	15.2.58	0·71, 0·60, 0·62, 0·68
3	18.2.58	1·33, 1·36
4	26.2.58	1·55, 1·50
5	26.2.58	1·20
6	27.2.58	0·62
7	27.2.58	
8	27.2.58	
9	1.3.58	0·53, 0·69
Mean		0·94
	Human non-smokers	
Subject		
A.P.	16.1.58	0·18
A.P.	17.1.58	0·09
E.H.	6.2.58	0·12
I.C.	6.2.58	0·15
R.B.	6.2.58	0·15
B.G.	6.2.58	0·15
G.M.	6.2.58	0·17
T.	15.2.58	0·19
R.M.	23.2.58	0·10
Mean		0·25

Table 2. Other Observations on the Blood of Weddell Seals

	Hæmatocrit per cent	Blood oxygen* capacity (vols. per cent S.T.P.)	Red blood corpuscles (million per cu. mm.)
Seals			
1	54		
2	54	30·8	
3	62	33·9	
4	65	34·0	3·85
5	60·5	30·6	3·62
6	61		
7	64		
8	55		
9	55		

* Corrected for residual carbon monoxide and dissolved oxygen.

Table 3. Hæmatological Values for two Weddell Seals (Nos. 4 and 5) compared with Normal Values for Man (ref. 4)

Sex	Red cell count (million per cu. mm.)	Hæmoglobin (gm. per 100 ml.)	Hæmoglobin oxygen capacity (ml. per 100 ml.)	Hæmatocrit per cent	Corpuscular values		
					M.C.V. (cu.μ)	*M.C.H.* ($\gamma\gamma$)	*M.C.H.C.* (per cent)
				Seals			
M	3·85	25·0*	34·0	65·0	169	65	38·5
F	3·62	22·5*	30·6	60·5	167	62	37·2
				Man			
M	5·4 ± 0·8	16·0 ± 2·0	21·9 ± 2·8	47 ± 7	87 ± 5	29 ± 2	34 ± 2
F	4·8 ± 0·6	14·0 ± 2·0	19·0 ± 2·8	42 ± 5	87 ± 5	29 ± 2	34 ± 2

* Calculated from oxygen capacity on the assumption that 1 gm. hæmoglobin combines with 1·36 ml. oxygen.
M.C.V, mean corpuscular volume; *M.C.H.*, mean corpuscular hæmoglobin; *M.C.H.C.*, mean corpuscular hæmoglobin concentration.

monoxide may also be oxidized in the muscles and in the blood[9,11-14]. The presence of carbon monoxide has been demonstrated in the blood of other animals as well as man; in cattle, sheep and pigs the values found by Sjöstrand[9] were intermediate between the present figures for human non-smokers and Weddell seals, namely, 0·3–0·59 vol. per cent.

In the light of these findings, the level of carbon monoxide in the blood of an animal at rest, and in the absence of absorption from without, can be regarded as representing an equilibrium between formation of carbon monoxide by the breakdown of hæmoglobin and its elimination via the lungs. The rate of formation will depend on the total quantity of hæmoglobin in the body and the survival-time of the red cells. Elimination will be governed by the carbon monoxide tension of the blood, the rate of ventilation of the lung alveoli and the diffusing capacity of the lungs for carbon monoxide.

Which of these factors might account for the high content of carbon monoxide in the blood in Weddell seals?

Total hæmoglobin. The hæmoglobin concentration in the seals examined was 40–50 per cent higher than the average value for human adults living at sea-level. No information is available on the blood volume of Weddell seals, but determinations on the related species *Phoca vitulina*[5] and *Cystophora cristata*[7] suggest that it might be at least 50 per cent higher in proportion to body-weight than in man. In this case the total amount of hæmoglobin in the body would be about twice as great as in man, and for a given red-cell survival-time, the rate of destruction of blood, and therefore formation of carbon monoxide, would also be twice as high. Consistent with this is the high bilirubin content of plasma from one of the Weddell seals. A high plasma bilirubin value has also been reported in *Phoca vitulina*[6].

Hæmolysis. We were impressed at Scott Base with the difficulty of preventing hæmolysis in samples of seal blood. Much greater care had to be taken with them than with human blood samples. Similar observations have been made by Harrison (personal communication). This observation suggests that the fragility of the red cells of seal blood may be greater than in man, and if this is so it would contribute to a high rate of destruction of blood.

Myoglobin. Another possible, though less important, source of carbon monoxide is the myoglobin muscle, which is present in high concentration in the muscles of seals and is responsible for their very dark colour. It has been estimated that the total amount of myoglobin in seals is equivalent to about 25 per cent of the total hæmoglobin[7]. Nothing is, however, known of the turnover of myoglobin in the body.

Ventilation. The following scattered pieces of information suggest that high carbon monoxide values in Weddell seals may be associated with their habit of sleeping for prolonged periods of time on the ice surface, during which their ventilation may be very low. Seals lying on the ice within sight of our camp could be seen in the same position for days at a time. The animals from which blood samples were taken had empty stomachs (apart from parasitic worms) and in some cases the intestines also were completely empty, suggesting that they had been out of the water for a considerable time. No attempt was made to study ventilation in Weddell seals. It was recorded, however, that during sleep their respirations were so infrequent that patience was needed to see them breathe at all. When startled they would rear up and turn their heads to look at the intruder, and one could see them open their slit nostrils to breathe 12–13 times a minute. According to the surface-volume law[15] the resting ventilation of Weddell seals weighing 250 kgm. would be expected to be about 25 per cent lower than in man, and if their respiratory quotient is of the order of 0·73 when in the fasting state[16], the ventilation during sleep may well be as little as 60 per cent of the corresponding resting value in man (respiratory quotient, 0·83), in which case pulmonary elimination of carbon monoxide would be reduced during sleep and the blood-level would gradually rise.

Later in the season three further blood samples were obtained from seals which had recently appeared on the ice in another place near open water. The stomachs of these animals were full of small fish (*Notothenia*). The carbon monoxide values were

Table 4. Acid-base and Electrolyte Determinations on a Specimen of Plasma, compared with Normal Values in Man

	Seal plasma	Human plasma (venous)
*p*H at 37° C.	7·43	7·34–7·44
CO_2 tension (mm. mercury)	40	40–52
Buffer base (m.equiv./l.)	44	46–52
Bicarbonate (m.equiv./l.)	25·8	23–29
Plasma cations (m.equiv./l.)		
Sodium	145	138–147
Potassium	8·2	3·9–5·0
Calcium	4·5	4·5–5·5
Magnesium	2	1–3
Total base (cations)	159·7	147–157
Plasma anions (m.equiv./l.)		
Bicarbonate	26	23–28
Phosphate	2	1·8–3·0
Proteins	16	15–19
Total buffer anions	44	42–48
Chloride	112	97–106
Undetermined anions	4	4–8
Total fixed anions	116	106–111
Total anions	160	147–157
Plasma protein (mgm. per cent)	6·7	6–8
Total non-protein nitrogen (mgm. per cent)	38	23–35
Total plasma carbon dioxide	27·5 m*M*/l.	

The undetermined anions are calculated by difference between the total fixed anions and plasma chlorides.

0·30, 0·45 and 0·67 per cent with hæmatocrits of 60·5, 63·5 and 55·0, respectively. Unfortunately, small clots were present in these samples, and the results were rejected. Later in England, an analysis was performed on a blood sample from a seal (*Phoca vitulina*) shot in the Wash by Prof. R. J. Harrison, and a carbon monoxide value of 0·19 vol. per cent was obtained. These seals, apart from their small size (that is, 25–50 kgm.), differ in their habits from Weddell seals in that they spend nearly all their time in the sea, coming out at low water on sandbanks exposed by the tide ; hence it may be assumed that their ventilation while they are at sea is high enough to keep down the level of carbon monoxide in the blood.

Low resting ventilation due to the factors mentioned above is consistent with a normal blood pCO$_2$ and pH such as was observed in the single plasma sample examined. It would not, however, be surprising to find hypoventilation with elevation of blood pCO$_2$, and high oxygen extraction-rates in seals at rest in the natural state, since there is experimental evidence that they are insensitive to carbon dioxide and also tolerate extremely low oxygen tensions[5,6]. This has not, however, been observed under experimental conditions[16].

Exogenous carbon monoxide. It remains to inquire whether there are any possible exogenous sources of carbon monoxide to which the Weddell seals near Scott Base might have been exposed. There is a remote possibility that carbon monoxide might be given off from the ooze on the sea bed and might be present in the ice pockets under the ice which seals are alleged to make use of; but there are no data to support this. Another possible source of carbon monoxide would be the neighbouring active volcanic Mount Erebus, but this is ruled out by the low values of carbon monoxide in persons at Scott Base who were non-smokers.

It seems reasonable to suggest, therefore, that the carbon monoxide in the blood of Weddell seals is the result of a balance between production of carbon monoxide in the body and elimination by the lungs, and that the high values reflect special features of the physiology of Weddell seals connected with their life under the ice and upon its surface.

Thanks are due to Mr. J. T. Murray, of Christchurch Hospital, Christchurch, New Zealand, who performed the acid-base and electrolyte determinations, and to Prof. R. J. Harrison for a blood sample from a harbour seal (*Phoca*).

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THE LYMPHOCYTE PROBLEM

By PROF. J. M. YOFFEY
Department of Anatomy, University of Bristol

THE lymphocyte has for many years confronted us with a two-fold problem. The first concerns the rate at which lymphocytes are formed, the second the fate and functions of the lymphocyte once it has been formed. The great interest of the problem resides in the fact that the lymphocyte is present from the very beginning of vertebrate evolution, and may be presumed to play an essential part in the life of the organism.

What is a Lymphocyte ?

The question : 'What is a lymphocyte ?' is not as simple to answer as many have thought. The lymphocyte is a mononuclear cell, with a nucleus which may be round or indented. Lymphocytes are roughly classified in accordance with size as large, medium or small. The larger cells possess a fair amount of cytoplasm, sometimes basophilic. The most numerous—and also the most controversial—lymphocytes are the small variety, in man about 8μ in diameter. These cells possess very little cytoplasm, often only a small tuft at one pole of the cell. The high ratio of nucleus to cytoplasm is very characteristic of the small lymphocyte, and has led many to conclude that this cell functions essentially through its nucleus, for example, as a carrier of deoxyribonucleic acid. The small lymphocyte is also capable of movement of a very distinctive type. The movement may start quite suddenly and end equally abruptly. The nucleus goes first, often forming a round head, while the scanty cytoplasm forms a short stumpy tail. When not moving, the cell becomes rounded once again. The small thymocyte moves in the same distinctive manner.

Where are Lymphocytes formed ?

Lymphocytes in mammals are formed in the lymphoid tissues, which are aggregates of several different kinds of cells among which the lymphocytes predominate. Lymphoid tissue is present in all vertebrates. In fishes, amphibians and reptiles it is closely associated with the myeloid tissues which give rise to the red cells and granular leucocytes (granulocytes), and together with these it constitutes the so-called lymphomyeloid organs. In birds and mammals, most markedly in the latter, the lymphomyeloid tissues dissociate, and the lymphoid tissues seem to be quite separate from the myeloid. But the separation is not as complete as would at first sight appear. Even in mammals, there are always large numbers of scattered lymphocytes to be found in the myeloid tissues, while on the other hand, myeloid cells may not infrequently develop in the lymphoid tissues.

The Lymphoid Complex

The lymphoid tissues in mammals form a complex consisting of: (*a*) lymph glands; (*b*) spleen; (*c*) subepithelial lymphoid tissues such as tonsils, adenoids, Peyer's patches and appendix; (*d*) thymus. The scattered nature of the lymphoid tissues makes it difficult to estimate their total amount, but they probably constitute 0·5–1·0 per cent of the weight of the body. The position of the thymus in the lymphoid complex has been repeatedly questioned, and it has been suggested that though the small thymocytes look very like the small lymphocytes they are in fact a different type of cell. On the whole, the balance of evidence appears to favour the inclusion of the thymus in the lymphoid complex, and there is even some evidence to suggest that it may play a dominant part. Differences between the various members of the lymphoid complex may be the result of circulatory and metabolic peculiarities. Thus, to give but one example, lymph glands are traversed by a stream of lymph, reaching them by afferent and leaving by efferent vessels. In the case of the mesenteric lymph glands, the afferent lymph vessels bring products of digestion, whereas in the case of the limbs, the lymph stream contains waste products of tissue metabolism.

Lymphocyte Formation

Lymphoid tissues were among the first animal tissues in which mitoses were described—by Flemming in 1885. He noted the presence in lymph glands of the characteristic lymphoid nodule, a light central area of larger cells surrounded by a peripheral zone of smaller cells. It was in the lighter area that Flemming observed numerous mitoses, and he considered them to be germinal centres, in which there was active cell proliferation. One also finds that cell multiplication can occur in diffuse lymphoid tissue, devoid of nodules. Lymphocyte formation is often at its most active in the thymus, where germinal centres are not normally found. The centres undergo cyclic changes; they are also readily damaged by a variety of toxic substances. There may be few or no mitoses in either the resting or the damaged germinal centres. In the active centre, the growing cells show rapid uptake of phosphorus-32 or tritiated thymidine, both of which become incorporated into newly formed deoxyribonucleic acid, and these substances can readily be identified in autoradiographs.

Estimation of Lymphocyte Production

The histological evidence indicates that lymphoid tissues are regions of active lymphocyte formation. Many, if not all, of the lymphocytes thus formed enter the blood. They may do so indirectly, first obtaining access to the lymph stream and then being conveyed by it to the blood; or directly, through the walls of blood capillaries in the lymphoid tissues. 'Direct entry' lymphocytes cannot be measured. 'Indirect entry' lymphocytes can be counted since the lymph of the entire body reaches the blood mainly through the thoracic duct, and to a lesser extent through the right lymph duct.

It is a relatively simple procedure in most animals to collect the lymph from the thoracic duct, and count the lymphocytes which would otherwise have gone into the blood. One can also estimate the total number of lymphocytes in the blood stream. These in health remain fairly constant, and there is no evidence that they are destroyed while in the blood. The number of lymphocytes entering the blood each day via the thoracic duct is sufficient in the dog to replace those already present in the blood about 2·5 times. This is called the 'daily replacement factor'. The only way then in which the blood lymphocytes can maintain a constant level is for some to leave the blood at the same time as other newly formed cells are entering it. This at once raises the problem: Where do the lymphocytes leave the blood?

Is there a Lymphocyte Circulation?

The continued entry into the bloodstream of large numbers of newly formed lymphocytes has been questioned by several observers, who have suggested that what is really happening is the continuous circulation of lymphocytes between blood and lymph. There is no doubt that a small proportion of lymphocytes do circulate in this way, and it may be that in some species the number of recirculating cells is greater than in others. But the evidence on the whole indicates considerable new formation of cells in the lymphoid tissues. This has been estimated by mitotic counts, and by the rapid uptake of labelled deoxyribonucleic acid precursors.

Fate of the Lymphocyte

There are not many regions of the body which might be in need of a constant influx of cells. The most probable tissue appears to be the bone marrow, and quantitative studies indicate that it has a surprisingly large population of lymphocytes, which do not appear to be formed in the marrow. But why should the marrow be in need of continual cellular replenishment? Many have held that the lymphocyte is a primitive and multipotential cell, capable of developing into the other blood cells. This view, however, has been strongly contested by others, who have maintained that the small lymphocyte is a mature cell without any developmental potentialities whatever.

Defence Function of Lymphoid Tissue: Genetic Plasticity

If the lymphocyte cannot function as a primitive multipotential cell, is there any other function which we can assign to it? It has been thought to possess a defensive role, and in recent years it has been shown that many of the cells in lymphoid tissue can produce antibodies to foreign protein. This is a remarkable property, which probably involves genetic changes in the cells. It requires a primitive and undifferentiated cell, presumably, to be able to develop new secretions in response to new stimuli. It is not difficult to accept the view that such a cell, capable of producing on demand a variety of antibody globulins, should also be able to give rise to substances such as hæmoglobin.

Cell Transfusion Experiments

The lymphoid cells, as also those of the bone marrow, are very sensitive to radiation. Severe radiation will kill the great majority of these cells, and after a while death of the organism results. It can, however, be prevented by giving the animal an intravenous transfusion of cells from the bone marrow of a normal animal. The transfused cells colonize the bone marrow of the recipient, as has been elegantly demonstrated by transfusing cells with unmistakable biological markings. If the lymphocyte is a primitive cell, then lymphocyte transfusions should protect in the same way; but there are no convincing experiments to this effect.

Marrow transfusion experiments do, however, show that the marrow can take up cells from the blood stream rapidly and in large numbers. In such cases there is, furthermore, rapid regeneration of thymus and lymph glands. In all these instances the transfused cells function presumably as homografts, and if so it would follow that transfused marrow cells can colonize lymphoid tissues. In fact, if a small amount of marrow is shielded during severe irradiation, recovery of the animal and regeneration of its lymphoid tissues will usually follow.

Cellular Migration Streams in the Normal Animal

The trend of work in recent years has been to suggest that, through the blood, lymphocytes may stream in either direction between the lymphoid complex and the bone marrow, and also between the different parts of the lymphoid complex. The thymus may exert some chemical influence on the other members of the lymphoid complex, or it may send continuous cellular reinforcements to them. The blood appears to be the great pathway for all these cellular migrations from one tissue to another.

ELECTRICAL DOUBLE LAYER IN COLLOID SCIENCE

NEARLY one hundred physical chemists, from academic and industrial laboratories, attended a one-day informal discussion sponsored by the Colloid and Biophysics Committee of the Faraday Society and held on September 16 in the Chemistry Department of the Royal College of Science, London, at the invitation of Prof. R. M. Barrer and his staff.

The practical significance of electrokinetic effects was reflected in the wide range of materials which had been studied by different speakers—for example, polyelectrolytes in solution, dispersions of inorganic oxides or synthetic resins, oil-in-water emulsions stabilized by monolayers of detergents or macromolecules, organic salts in non-aqueous solvents (relevant to the paint and petroleum industries), a concentrated inorganic sol, and membranes of ion-exchange resins (similar to those now coming into use for electrodialytic de-salting of brackish water).

Four of the electrokinetic effects were discussed, namely, electrophoresis, streaming currents, electroviscosity and electro-osmosis; but it is recognized that these are equivalent experimental means of studying the mechanical properties of the electrical double layers which are to be found at almost all interfaces, and which are largely responsible for such widely different practical effects as, for example, the stability of soap emulsions, stickiness of clay soils, and the dangerous electrostatic charges sometimes encountered when petroleum products are pumped through metal pipes. The discussion, however, was concerned with fundamental problems of the origin and structure of double layers and the quantitative theory of their effects. These are by no means new problems; but as the chairman, Sir Eric Rideal, reminded the meeting, electrokinetic effects are among the easiest to detect and the most difficult to interpret.

Prof. J. Th. G. Overbeek and Dr. B. van Geelen (Utrecht) reported a comprehensive study of electrophoresis and electrical transport in solutions of polymethacrylic acid partially neutralized by sodium hydroxide and containing between 10^{-4} and 10^{-1} M sodium chloride. The mobility of the chloride ions is little affected by the presence of the poly-ions (from which, of course, they are repelled), but the mobility of the sodium counter-ions is low, particularly when the polymethacrylate ions are highly charged and the ionic strength is low; indeed, the majority of the counter-ions are then carried along with the poly-ions. The mobility of the poly-ions increases, as to be expected, with increasing charge, though less than linearly. Quantitative treatment of such effects in terms of current theories[1] of polyelectrolytes is only partially successful. Rather drastic refinements will have to be introduced into the theories. It was pointed out that in electrophoresis of polyelectrolytes the polymer coil is more nearly 'free-draining' than in sedimentation or diffusion because of the migration of the counter-ions through the coil.

Dr. P. J. Anderson (Atomic Energy Research Establishment, Harwell) surveyed recent studies[2] of dispersions of several inorganic oxides (for example, the dioxides of titanium, zirconium and thorium) in dilute inorganic electrolytes. The electrophoretic velocities of the particles were translated into ζ-potentials and electrokinetic charge densities (σ) by use of the standard Gouy–Chapman theory and its modern refinements for electrophoresis (Henry, Overbeek). The values of σ, regarded as due to adsorption of ions from solution on to an inert surface, provide an adsorption isotherm which is generally of the Langmuir form, and the constant of the isotherm is a measure of the adsorbability of the ions. The usual effects of ion valence are found with the oxides, provided allowance is made for specific (chemical) effects of lattice ions, and the order of adsorbability in a series of ions of given valence can often be correlated with their polarizabilities, etc. An outstanding problem is why saturation of adsorption, calculated from the isotherms, would correspond to only about 1 ion per 1000 A.^{2} of surface, or 1 per cent of the surface available. If the adsorption model is a valid interpretation of electrokinetic data for such surfaces, the results suggest that adsorption occurs only on special sites—perhaps point defects or dislocations.

Dr. D. A. Haydon (Imperial College of Science and Technology, London) discussed the results of a critical investigation of the interface between petroleum ether and solutions of sodium dodecyl sulphate and dodecyl trimethylammonium bromide in water, with and without excess sodium chloride. The surface charge densities (σ) of adsorbed detergent were determined from measurements of interfacial tension by application of the Gibbs equation (in its appropriate forms). From these results a surface potential (ψ_r) was calculated, assuming a Gouy-type diffuse double layer of counter-ions, but with allowance for the size of the ions. Stern adsorption, on the available independent evidence, was considered unlikely in this system. The ψ_r-potentials so obtained were in reasonable agreement with phase-boundary potentials determined directly by a vibrating-plate electrometer, though the latter were slightly lower with substrate concentrations above 0·01 *M*, suggesting that a small proportion of the counter-ions penetrates between the detergent ions. A striking difference, however, was found between the ψ_r-potentials and the ζ-potentials determined by microphoresis; ζ was always less than ψ_r, often less than $\frac{1}{2}\psi_r$. Furthermore, changes of ζ and ψ_r did not necessarily follow one another in sign; in the presence of excess sodium chloride ζ passed through a maximum with increasing concentration of anionic detergent, whereas ψ_r showed no maximum, nor was a maximum exhibited by the cationic detergent. These results seem to point to the conclusion that only a fraction of the diffuse double layer is sheared off in electrokinetics, the 'plane of shear' depending on ψ_r and on charge density, which perhaps cause some modification of the properties of water in the vicinity of the fixed monolayer. In discussion, Prof. Overbeek mentioned calculations which suggest that water might be immobilized in that part of the double layer where the field strength is greater than about 500,000 V. cm.$^{-1}$.

These ideas were supported by Dr. J. A. Kitchener and Dr. J. H. Schenkel (Imperial College of Science and Technology, London), who had made electrophoretic measurements in the course of studying the stability of a model suspension consisting of 10-μ spheres of surface-sulphonated polydivinyl benzene resin. The surface charge density of ionizing —SO_3H groups, determined by ion-exchange, was of the order of 10^5 e.s.u. cm.$^{-2}$, but σ calculated from the mobilities was only around 2×10^3 and, surprisingly, increased with addition of indifferent electrolyte. Since adsorption of co-ions on this highly ionogenic surface seems most unlikely, the results suggest a variable plane of shear in electrophoresis, an idea which was supported by the observation that ζ was reduced by addition of a non-ionic polymer. However, the system is complicated by the polyelectrolyte character of the surfaces, and Dr. D. C. Henry (Manchester) mentioned that in recent measurements of the surface conductivity of a similar material he had obtained much higher values than any previously reported for this quantity and suggested that a correction for the influence of surface conductivity might remove some of the anomalies.

Dr. H. W. Douglas (Liverpool) reported an investigation of the electrophoresis of a synthetic polycarboxylic acid having a hydrocarbon–ester backbone and an equivalent weight of about 250. This polyelectrolyte was studied in free solution in a Tiselius apparatus and also adsorbed on oil droplets (by the microscopic method). The mobility increased with *p*H from 2 to 6 and remained constant from 6 to 9; it decreased with increase of ionic strength. It was remarkable that the mobilities of the poly-ions were very similar to those of the coated droplets. (Prof. Overbeek confirmed this also for polymethacrylic acid.) The surface charge density at high *p*H was estimated to be around 50,000 e.s.u. cm.$^{-2}$, which was five to ten times that found by electrophoresis. Again a strong retention of counter-ions near the poly-ion is indicated. Furthermore, σ calculated from electrophoresis was found to increase with increasing concentration of sodium chloride at, for example, *p*H 9.

A paper by Prof. A. J. Rutgers (with Drs. M. de Smet and W. Rigole, of the University of Ghent) on streaming currents with non-aqueous solutions provided a glimpse of a different aspect of electrokinetics[3]. Prof. Rutgers described new results for solutions of tetra-*iso*-pentile ammonium-picrate in benzene (0–1,000 μmole/l.) streaming through long capillaries of various widths, wide capillaries of various lengths, a cylindrical slit or a system of closely fitting glass rings. Under some conditions, turbulence occurred with a consequent non-linear increase of the streaming current with increase of pressure. The currents were very small (10^{-13}–10^{-11} amp.) and special precautions were taken to collect them without loss. High ζ-values (for example, −280 mV.) were obtained with dilute solutions provided the capillaries were wide enough to exceed the thickness of the double layer, and long enough to exceed the value $V\tau$, where τ is the time of relaxation of the solution and V the mean velocity. A quantitative treatment of the effect of length and width of the tube has been developed, with allowance for the current carried by conduction and convection and by the glass itself. As predicted from the equations, a potential of several volts can be detected with dilute solutions flowing through a glass capillary.

Dr. R. H. Ottewill (Cambridge) reported work on the electro-viscous effect which he had carried out with Prof. Overbeek at Utrecht[4]. The effect is the apparent enhancement of viscosity observed in colloidal solutions or suspensions owing to the presence of electrical double layers around the particles. (With solutions of polyelectrolytes another factor, the expansion of the macromolecules, is sometimes also included under the term 'electroviscous effect'.) The system studied was a concentrated sol of silver iodide. The volume concentration and total electrolyte concentration were varied, and the apparent viscosity determined in a capillary viscometer at mean shear rates ranging from 200 to 2,000 sec.$^{-1}$. At high concentrations of electrolyte the viscosity was practically Newtonian and could be accounted for by purely hydrodynamic interaction between the suspended particles. In dilute solutions of electrolyte a strong electroviscous contribution enhanced the viscosity. Furthermore, the viscosity decreased with increasing rate of shear. The effects can be understood in terms of interaction between the diffuse double layers of neighbouring particles: at high rates of flow the counter-ion cloud becomes elongated and therefore interacts less with that of particles in adjoining flow lines.

The final two papers were concerned with a very different system, namely, membranes of ion-exchange resin. Electro-osmosis in such resins was first proved by the observation that their electrical conductivity is significantly higher than can be accounted for by the intrinsic mobility of the mobile ions ('internal counter-ions'), as determined by measurements of self-diffusion. It is clearly demonstrated by the fact that the passage of an electrical current through the material transports water in the direction of movement of the counter-ions. The system differs from the capillaries and porous plugs of classical electro-osmosis in that the solid wall is here replaced by a cross-linked polymer network and the inter-chain distance is not much greater than the mean distance of spread of the counter-ions from the chains. Despite superficial differences, therefore, this system has certain similarities to the polyelectrolytes considered in earlier papers in the discussion.

Drs. D. Mackay and P. Meares (Aberdeen) reported systematic studies[6] of electrical conductivity and electro-osmotic water transport through a highly swollen membrane of a phenolsulphonic acid resin in sodium form and in equilibrium with sodium chloride solutions of 0·01–1 *M* sodium chloride at 15°, 25° and 35° C., and also with mixed sodium and hydrogen forms of resins at two concentrations of electrolyte. These results were interpreted in conjunction with those previously obtained for the self-diffusion of sodium and chloride ions through the same resins. It appears that the conductivity of the sodium form of the resin in contact with very dilute solutions is simply equal to the sum of the ionic mobilities and electro-osmotic velocity; but at higher concentrations the conductivity is lower than that calculated in this way. It was suggested that this might be due to decreasing electro-osmotic velocity and particularly to its effect on the mobility of co-ions, which apparently have a different migration mechanism from the counter-ions. The velocity of electro-osmotic streaming of solution through the membrane was found to be proportional to the potential gradient.

In contrast to this result, Drs. G. J. Hills, P. W. M. Jacobs and N. Lakshminarayanaiah (Imperial College of Science and Technology, London) reported that they had repeatedly observed that the volume of solution electro-osmotically transported per faraday increased with decreasing current density in the range below 20 m.amp. cm.$^{-2}$: the effect seemed to be well outside the experimental errors. However, at higher current densities the anomaly disappeared. Measurements on membranes of polymethacrylic acid and phenolsulphonic acid in equilibrium with dilute aqueous solutions of the chlorides of lithium, sodium, potassium, rubidium and cæsium were reported. Water-transport was a little greater with lithium than with cæsium, but considerably greater in the phenolsulphonic acid membrane than in the polymethacrylic acid (for example, 28 moles of water per mole of sodium ion in the former, compared with 11 in the latter). Part of this water might be carried in a solvation sheath and the remainder by 'electro-convection', that is, by flow of the internal solution. However, attempts to separate the two by calculating a mean electro-convective velocity from a combination of electrical conductivity and self-diffusion coefficients, using the Nernst–Einstein equation, have not been encouraging. The difficulty probably arises from the non-uniform composition of the mobile medium inside the internal diffuse double layer. In this system, therefore, as in electrophoresis, a more precise model of the double layer seems to be called for if a quantitative treatment of the electrokinetic effects in terms of structure is to be achieved.

Dr. Hills emphasized in a discussion with Prof. Rutgers that he did not think that a classical electrokinetic approach to transport in ion-exchange membranes was appropriate.

J. A. KITCHENER
D. A. HAYDON

[1] Hermans, *J. Polymer Sci.*, **28**, 527 (1955). Overbeek and Stigter, *Rec. Trav. Chim.*, **75**, 543 (1956). Fujita, *ibid.*, **76**, 798 (1957). Longworth and Hermans, *J. Polymer Sci.*, **26**, 47 (1957). van Geelen, Ph.D. thesis (Utrecht, 1958).

[2] Anderson, Proc. Second Int. Congr. Surface Activity, 1957, **3**, 67; *Trans. Faraday Soc.*, **54**, 131, 562 (1958).

[3] cf. Rutgers *et al.*, *Trans. Faraday Soc.*, **48**, 635 (1952); **53**, 393 (1957).

[4] cf. Harmsen, van Schooten and Overbeek, *J. Colloid Sci.*, **8**, 64 (1953).

[5] cf. Meares, *J. Chim. Phys.*, **55**, 273 (1958).

THE YARD AND THE POUND (AVOIRDUPOIS) FOR SCIENCE AND TECHNOLOGY

THE directors of the following standards laboratories have discussed the existing differences between the values assigned to the yard and to the pound in different countries: Applied Physics Division, National Research Council, Ottawa, Canada; Dominion Physical Laboratory, Lower Hutt, New Zealand; National Bureau of Standards, Washington, United States; National Physical Laboratory, Teddington, United Kingdom; National Physical Research Laboratory, Pretoria, South Africa; and National Standards Laboratory, Sydney, Australia. To secure identical values for each of these units in precise measurements for science and technology, it has been agreed to adopt an international yard and an international pound having the following definitions: the international yard equals 0·9144 metre; the international pound equals 0·453 592 37 kgm.

It has also been agreed that, unless otherwise required, all non-metric calibrations carried out by the above laboratories for science and technology on and after July 1, 1959, will be made in terms of the international units as defined above or their multiples or submultiples.

The new international units conform with the recommendations of the Board of Trade Departmental Committee on Weights and Measures Legislation (the Hodgson Committee), but the Board of Trade points out that the units will have no statutory force and may not be used for trade purposes in the United Kingdom. The yard and pound units to be used in trade are the imperial units laid down in the Weights and Measures Act, 1878.

The values of the yard currently in use in the British Commonwealth and the United States of America are as follows, when expressed in terms of the metre: 1 imperial standard yard = 0·914 397 2 metre; 1 Canadian yard = 0·9144 metre; 1 yard as at present used by the National Physical Laboratory for science and technology, based on the 1922 value of the imperial standard yard = 0·914 398 41 metre; 1 United States yard = 0·914 401 83 metre.

As the imperial standard yard is about 5 parts per million (0·0002 inch) less than the United States yard (which is defined in terms of the metre) and is shortening at the rate of more than one-millionth of an inch per annum, the consequent discrepancies in measurements of length are important in modern precision engineering. To give two examples, it is necessary to know the lengths of the highest grade block gauges accurately to one part per million, and the permissible error on accurate yard scales is 0·0001 inch. Though the National Physical Laboratory, by using the metre and wave-lengths of light and by adopting the 1922 value of the imperial standard yard in relation to the metre, has been able to stabilize its basis of reference for length measurements in terms of the yard and its common sub-multiples for science and technology, unification of the yard standard for these purposes in the British Commonwealth and the United States can no longer be delayed.

With regard to the pound, the values currently in use when expressed in terms of the kilogram are: 1 imperial standard pound = 0·453 592 338 kgm.; 1 Canadian pound = 0·453 592 43 kgm.; 1 United States pound = 0·453 592 4277 kgm.

There is evidence that the imperial standard pound has diminished by about 7 parts in 10 millions since 1846. It is about 2 parts in 10 millions (0·0014 grain) smaller than the United States and Canadian pounds, which are defined in terms of the very closely safeguarded international prototype kilogram. Though the discrepancy between the pounds is not at present causing any technical difficulty, the co-existence of independently defined pounds is unsatisfactory in science and technology.

The agreed international values of the yard and the pound fall between the existing United States and British units, and the international yard, which is the same as the Canadian yard, accords exactly with the relationship 1 inch = 25·4 mm., which is already extensively used in Great Britain and abroad for approximate conversions. The adoption of the international values of the yard and the pound will be of particular benefit to all those concerned with accurate measurements of length and mass for scientific and technological purposes in the British Commonwealth and the United States.

OBITUARIES

Dr. John Jackson, C.B.E., F.R.S.

Dr. John Jackson died in Epsom Hospital on December 9 at the age of seventy-one. His interest in astronomy was aroused when he studied under Prof. Ludwig Becker at the University of Glasgow. There he received a thorough grounding in celestial mechanics and in spherical astronomy. From Glasgow he proceeded to Trinity College, Cambridge, and was placed among the Wranglers as a result of the Mathematical Tripos Examination in 1912 and was awarded the Tyson Medal and Sheepshanks Exhibition. In 1914 he received the first Smith's Prize.

His attention was directed to the problem of retrograde satellite orbits and, in particular, to the motion of Jupiter's eighth satellite. This satellite had been discovered by Melotte at the Royal Observatory, Greenwich, in 1908. It was the first satellite of Jupiter with a retrograde motion to be discovered and, because of the perturbing action of the Sun, its movement is very complicated. Observations of this satellite are difficult to obtain and are few in number, so that its orbit is even now rather uncertain. In 1914 Jackson was awarded the Mackinnon Studentship of the Royal Society for research on the motion of this satellite, but shortly afterwards he was appointed chief assistant at the Royal Observatory, Greenwich. He remained there for nineteen years and, during that time, he entered fully into all the programmes of observation that were undertaken.

His first important work at Greenwich was concerned with the observations of binary stars that had been made there with the 28-in. refractor over a period of many years. These observations had been published in the annual volumes of Greenwich Observations, but no use had been made of them. He determined the orbits of a number of these binary systems, and combined the observations made at Greenwich with those that had been made elsewhere. For many of the systems, the periods of which were long, observations have not been extended over sufficient years for orbits to be derived; but the observations of these systems were used to infer their parallaxes and Jackson derived the hypothetical parallaxes of 556 systems.

In 1924 the Shortt free-pendulum clocks were introduced at the Observatory as the standards of time, replacing the regulator clocks that had previously been used. Jackson, in conjunction with W. Bowyer, discussed their performance and showed that, as a result of the nutation of the Earth's axis, sidereal time was not uniform. As a result of these investigations, astronomers have since had to distinguish between apparent and mean sidereal time. Jackson looked into the possibility that the accurate time-keeping of these clocks might provide information about the variability in the rotation of the Earth, but concluded that they were not sufficiently accurate to give trustworthy determination of the variability.

Another important piece of work, undertaken in collaboration with Dr. H. Knox-Shaw, the Radcliffe Observer at Oxford, and his assistant, Mr. Robinson, was a careful reduction of the observations of the Sun, Moon, planets and stars, which had been made at the Radcliffe Observatory, Oxford, during the years 1774–98 by Hornsby. These observations had not been reduced and, for their epoch, were of high accuracy. Such early positions of these bodies are of value in connexion with the determination of the proper motions of the stars, and the investigation of the orbits of the Sun, Moon and planets.

In 1933 Jackson was appointed H.M. Astronomer Royal at the Royal Observatory, Cape of Good Hope, and held that position until his retirement in 1950, when he returned to Great Britain to take up residence. The Cape Observatory has a long tradition of accurate meridian and astrometric observations. The principal programmes of observation undertaken during Jackson's tenure of office were fundamental meridian observations with the Gill transit circle, the determination of positions and proper motions of stars, the determination of parallaxes of southern stars and the preparation of a photographic catalogue of southern stars between 30° S. and the South Pole.

Under his direction, Dr. R. H. Stoy, who, on Dr. Jackson's retirement, succeeded him as H.M. Astronomer, undertook the determination of the magnitudes of the brighter southern stars, which has established the photometry of the southern stars on a satisfactory and accurate basis.

During the Second World War the staff at the Observatory was much reduced, many members having left to undertake war-work of various sorts. Nevertheless, the output of observations continued at a remarkably high rate, Dr. Jackson himself being an assiduous observer.

Among his other interests was the observation of total eclipses of the Sun. While at Greenwich he obtained successful observations of the total eclipse of 1927 at Giggleswick and that of 1932 at Parent in Canada. He had also led an eclipse expedition to Alor Star, Kedah, Malaya, in 1929, when clouds unfortunately prevented observations being obtained. In 1940, when the War prevented the eclipse expedition from Greenwich proceeding to South Africa for the observation of the total solar eclipse in that year, the instrumental equipment was sent to South Africa, and under Jackson's direction the eclipse was observed under clear conditions at Calvinia in Cape Province.

Dr. Jackson was elected a Fellow of the Royal Astronomical Society in 1913 and served as secretary during 1924–29. After his return to Britain he was elected president of the Society for the period 1953–55. He was elected a Fellow of the Royal Society in 1938. He was president of the Commission on Meridian Astronomy of the International Astronomical Union during 1935–38, and president of the Commission on Parallaxes and Proper Motions during 1938–52. In 1952 he was awarded the Gold Medal of the Royal Astronomical Society for his work on stellar parallaxes and his contributions to the general problems of star positions and proper motions. Last year he was awarded the Gill Medal of the Astronomical Society of South Africa for his important contributions to astronomy during his period as H.M. Astronomer. He was made C.B.E. in 1950.

H. SPENCER JONES

Sir James Myers, O.B.E.

SIR JAMES MYERS, whose death was reported recently, had been associated with Manchester throughout his academic life. He was graduate in chemistry of Manchester, he served for a period as senior lecturer in chemistry and as secretary and tutor of the Faculty of Science of the University, and then, after a period as principal of the Manchester College of Technology, he was director of the School of Education of the University of Manchester.

Sir James was principal of the Manchester College of Technology during 1938–51—a period of very obvious difficulty. He had been a prominent member of the Faculty of Science in the University of Manchester, and it was hoped that he would consolidate relationships between the College as the Faculty of Technology and the rest of the University; instead, he was thrust into the hurly-burly of adaptation to the war effort. Under his guidance the College performed sterling work in both the educational and industrial fields.

There is little doubt, however, that he was not in his element in this sort of capacity; he preferred a slower-moving philosophical life. This was not to be, however. When the War ended, the College was one of the first university institutions to proceed with extensions, and the trials and tribulations of this activity again fell largely on his shoulders. It was not surprising that, in 1951, after receiving a knighthood for his services to technological education, he withdrew to the more peaceful pastures of the School of Education in Manchester.

I had the privilege of working under him for six years. He was a delightful person to know—full of warm humanity, of witty stories told with a strain of philosophy that left its mark, of wise advice to his subordinates. He was a gentleman in every sense of the word, and his influence on the College will be felt for a long time.

H. LIPSON

Dr. Kenneth W. Neatby

DR. KENNETH W. NEATBY, director of Science Service in the Canada Department of Agriculture, died on October 27. His death will be a very distinct loss to agricultural science and particularly to his own Service, which he has been directing for the past twelve years, and in which he was successful in building an effective research atmosphere. During the spring and summer of 1958, he had been instructed to take the lead in the formation of a Research Branch in the Canada Department of Agriculture through the amalgamation of Science Service and the Experimental Farms Service.

Dr. Neatby's career in research began with his appointment, in 1926, to the staff of the Dominion Rust Research Laboratory in Winnipeg. In addition to the actual development of varieties of wheat that were resistant to stem and leaf rust, he began a series of intensive studies of the inheritance of resistance to rust in wheat. Out of his work there came a much clearer understanding of the relation between the genes for resistance to rust and the various physiological races of the rust organism. This formed the foundation for work that is still going on and becoming increasingly valuable in our understanding of the cereal rust problem.

In 1935, Dr. Neatby went to the University of Alberta in Edmonton as head of the Department of Field Crops. This was perhaps the beginning of his intense interest in education, particularly for a research career in biology. His writings and addresses on this subject have undoubtedly had an important influence on the course of agricultural education and research in Canada. Some excerpts from an address given at Macdonald College are examples of his thinking: "The student who allows the laboratory to keep him from the library, thereby depriving himself of the influence of great men of the past in other fields of learning, as well as his own, may become a competent technician but he is unlikely to become an influential scientist." "We hear a lot about training for research, but surely this is either a contradiction in terms or a misapplication. Fruitful research depends on knowledge, imagination, ideas and dogged perseverance, not on techniques derived by formal training, essential as these may be."

During 1940–46, Dr. Neatby was director of the Farm Service of the North-West Line Elevators Association at Winnipeg. Here, he gained a first-hand knowledge of agricultural problems and became very conscious of the need for first-class research work in agriculture. From 1946 on, as director of Science Service, he built up an organization which has become very well known for its contributions in biology.

C. H. GOULDEN

NEWS and VIEWS

The Russian Artificial Planet

THE final stage of a Russian multi-stage rocket, launched at about 17.00 hr. U.T. on January 2, flew past the Moon to become the first artificial planet of the Sun. The final-stage rocket is stated to have weighed 1,472 kgm. (3,245 lb.) after all its fuel was burnt, and its pay-load of scientific instruments, together with the container, weighed 361·3 kgm. (797 lb.). The instruments were intended to measure the Moon's magnetic field, the intensity and composition of cosmic rays, lunar radioactivity, the impact of meteors and the composition of the Moon's atmosphere. The rocket was also equipped with radio transmitters operating on some or all of the frequencies 183·6, 19·997, 19·995, 19·993, 71·2 and 212 Mc./s. The programme of scientific measurements is stated to have been successfully accomplished before radio contact was lost on January 5.

The rocket left the Earth with a speed of 7 miles/sec., and when it was about 75,000 miles out, at 00.57 hr. U.T. on January 3, it emitted a cloud of sodium vapour which was observed from the Earth as a glow in the constellation of Virgo. By 10.00 hr. U.T. on January 3 the rocket was 130,000 miles from the Earth's surface, at longitude 40° W. and latitude 8° S. The rocket passed the Moon, at a distance of 4,700 miles from its surface, at 02.59 hr. U.T. on January 4 and was then moving at a speed of 1·5 miles/sec. away from the Earth. Since the Moon was near last quarter at the time of the launching, the rocket's path was nearly tangential to the Earth's orbit; the rocket's orbit around the Sun, therefore, has almost the same perihelion distance as the Earth's orbit, though the aphelion distance is greater, because of the rocket's greater speed at perihelion. Its orbit is inclined at only a small angle to the plane of the ecliptic and the distance from the Sun is expected to vary between a minimum of 91 million miles and a maximum of 122 million miles. The period of revolution will be about 450 days, with the first perihelion on about January 14.

New Year Honours

THE following names of scientists and others associated with scientific work appear in the New Year Honours list:

Baronet: Kenneth W. M. Pickthorn, during 1935–50 member of Parliament for the University of Cambridge, for political and public services.

C.H.: Sir John Beazley, emeritus professor of classical archæology, University of Oxford, for services to scholarship.

Knights: Prof. Alexander W. G. Ewing, director of the Department of Education of the Deaf, University of Manchester; Stuart Gillett, lately chairman of the Tanganyika Agricultural Corporation; Henry R. F. Harrod, University lecturer in economics, University of Oxford; Dr. Reginald P. Linstead, rector of the Imperial College of Science and Technology, University of London; Dr. Douglas W. Logan, principal of the University of London; Kelvin T. Spencer, chief scientist, Ministry of Power; Prof. Arthur P. Thomson, professor of therapeutics and dean of the Medical School, University of Birmingham.

K.B.E.: Albert E. Axon, chancellor of the University of Queensland, for public services; George W. H. Gardner, director of the Royal Aircraft Establishment, Farnborough (Ministry of Supply); Prof. Marcus L. E. Oliphant, director of the School of Research in Physical Sciences, National University, Canberra; Geoffrey S. Peren, principal of Massey Agricultural College, New Zealand; Sir George Wilson, chairman of governors, West of Scotland Agricultural College.

C.B.: Air Commodore R. H. E. Emson, director of air armament research and development, Ministry of Supply; W. B. Littler, director-general (scientific research (munitions)), Ministry of Supply; J. W. Stork, director of studies, Britannia Royal Naval College, Dartmouth; A. A. Part, under-secretary, Ministry of Education.

C.M.G.: T. H. Searls, lately director, Universities and Adult Education Department, British Council; Prof. H. C. Webster, professor of physics, University of Queensland, for services to the Federal Government of Australia.

C.B.E.: Dr. Muriel E. Bell (Mrs. Hefford), nutritionist to the Department of Health and superviser of Nutrition Research, Department of Medical Research Council, New Zealand; M. M. Burns, director of Canterbury Agricultural College, Christchurch, New Zealand; W. A. S. Butement, chief scientist, Department of Supply, Australia; Dr. M. Cook, chairman of the Metals Division, Imperial Chemical Industries, Ltd.; I. J. Cunningham, superintendent of the Animal Research Station, Wallaceville, New Zealand; Dr. I. de Burgh Daly, lately director of the Institute of Animal Physiology, Babraham, Cambridge (Agricultural Research Council); Capt. N. Fawcett, H.M. chief inspector of explosives, Home Office; P. T. Fletcher, deputy managing director, Industrial Group Headquarters, Atomic Energy Authority, Risley; T. A. Lang, associate commissioner, Snowy Mountains Hydro-Electric Authority, Australia; A. B. Lilley, medical director of the Cancer Council, New South Wales; S. C. Longhurst, lately a member of the Forestry Commission; R. A. Lovell, chief mechanical engineer, Ministry of Transport and Civil Aviation; Prof. W. T. J. Morgan, professor of biochemistry, University of London, and member of the Biological Research Advisory Board, Ministry of Supply; Dr. H. J. Plenderleith, keeper in the British Museum; Dr. E. E. Pochin, director of the Department of Clinical Research, University College Hospital Medical School (Medical Research Council); J. A. Ratcliffe, chairman of the Radar and Signals Advisory Board, Ministry of Supply Scientific Advisory Council, reader in physics, University of Cambridge; R. H. Schlotel, director of engine research and development, Ministry of Supply; R. B. Tennent, director of agriculture, New Zealand; Dr. H. W. Thompson, lecturer in chemistry, University of Oxford, senior regional scientific adviser for civil defence, Southern Region; Prof. S. J. Watson, professor of agriculture and rural economy, University of Edinburgh.

U.K. Atomic Energy Authority, Metallurgy Division: Mr. L. Grainger

Mr. L. Grainger has been appointed head of the Metallurgy Division of the United Kingdom Atomic Energy Authority's Research Group at Harwell. He is to succeed Dr. H. M. Finniston, who is being released by agreement to take up appointment with the Nuclear Power Plant Co. Mr. Grainger was born in Sheffield, in 1917, and was educated in Detroit but returned to England in 1933. He was in steel works until the War. He then joined the Admiralty and served with the Royal Air Force as fighter controller during 1943–47, afterwards returning to the Royal Naval Scientific Service to work on co-ordination of metallurgical research, particularly brittle fractures, creep testing, and development of new structural materials. He joined the U.K. Atomic Energy Authority in 1951, and later became head of Laboratories, Research and Development, Springfields. In 1955, he moved to Risley as chief metallurgist in the Research and Development Branch, becoming deputy director of research and development in 1958. He is the author of "Uranium and Thorium" (Newnes, 1958).

British Cast Iron Research Association:

Dr. J. G. Pearce, C.B.E.

Dr. J. G. Pearce, who has been director of the British Cast Iron Research Association since 1924, is to retire. During his tenure of the office he has seen the Association grow steadily both in size and importance. A graduate of the University of Birmingham, he has built up an international reputation and among other distinctions he has received the honorary doctorate of engineering of the University of Aachen. In 1957 he was made C.B.E. A member of the Worshipful Company of Founders, the Livery recently conferred on him its Founders' Medal for his services to the "art and mystery" of iron-founding. Before going to the British Cast Iron Research Association, Dr. Pearce was associated with Sir Arthur Fleming in the planning and organization of the Research and Education Department of the Metropolitan-Vickers Electrical Co., Ltd., and was co-author with Sir Arthur of two text-books on apprentice training and industrial research. He has served on many national and international committees and, since 1935, has, among other responsibilities, been chairman of the main committee on cast iron of the British Standards Institution.

Mr. H. Morrogh

Mr. H. Morrogh, at present deputy-director of the British Cast Iron Research Association, has been appointed to succeed Dr. J. G. Pearce as director. Educated at the George Dixon Grammar School, Birmingham, he joined the Association's staff in 1933 and became research manager in 1945. His main work, for which he has received international recognition, has been in connexion with the microstructure of cast irons, and in particular the identification of inclusions and the formation of graphite. It was from the latter work that the discovery of nodular graphite iron, perhaps the most important discovery ever made so far as this material is concerned, was announced in 1948. These contributions have been recognized by the award of gold medals by the Iron and Steel Institute, the Institute of British Foundrymen and the American Foundrymen's Society. He speaks with absolute authority in his own field, and although he himself received no university training, Mr. Morrogh has persistently encouraged higher metallurgical education, not only in the universities but also in the colleges of technology.

Vincenzo Lunardi (1759–1806)

Vincenzo Lunardi, who was born two hundred years ago on January 11, 1759, at Lucca in Tuscany, is remembered for having introduced aerostation into Britain. Joseph and Jacques Montgolfier constructed the first fire balloon, in which a sheep, a cock and a duck ascended on September 19, 1783. The first aeronaut in France was Pilâtre de Rozier later that year, and the first in Scotland was James Tytler on August 27, 1784. On September 15, 1784, on the Artillery Ground at Moorfields, the physician-chemist, George Fordyce, inflated a balloon, 33 ft. in circumference, with hydrogen before some 200,000 impatient spectators. Its passengers were a pigeon, a dog, a cat and Lunardi, who was secretary to Prince Caramanico, the Neopolitan ambassador. Lunardi had arranged to take an Englishman with him, but as there was insufficient hydrogen to sustain the extra weight, he was compelled to go alone. The balloon was provided with oars intended to raise or lower it at will, but one oar broke and fell to the ground. After 1½ hr. Lunardi descended at South Mimms in Hertfordshire to land the cat, which had suffered from the cold—the pigeon had already escaped—and made a second descent three-quarters of an hour later near Ware, having drifted twenty-four miles. This exploit excited enormous enthusiasm, and the balloon was exhibited for profit at the Lyceum in the Strand. In the following year Lunardi made several successful ascents from Kelso, Edinburgh and Glasgow. His letters to his guardian, Chevalier Compagni, which were published, contain a vivid account of his pioneer ventures. A strikingly handsome man, Lunardi died on July 31, 1806, at the age of forty-seven.

Building Research

The Lord President of the Council and the Minister of Works have decided that the Department of Scientific and Industrial Research should in future be the only Government department with responsibility for building research. Hitherto, the Ministry of Works has shared this responsibility through the Advisory Council on Building Research and Development. This Council, which was set up in 1947, and has made a most valuable contribution to the whole field of building research, will therefore not be continued after its present two-year period expires in March. To ensure continuity of the work previously undertaken by the Advisory Council, the Department of Scientific and Industrial Research will invite the various sections of the building industry to nominate representatives to a Standing Conference on Building Research and Development. The Ministry of Works will continue to provide the present service of advisory leaflets, lectures and the technical information service.

United States Atomic Energy Commission Charges for Uranium-233 and Plutonium

The United States Atomic Energy Commission has established the charges at which uranium-233 and plutonium will be made available for use in research and development to private individuals and companies in the United States and to foreign governments under agreements for co-operation, at

15 dollars per gram of uranium-233 and 12 dollars per gram of plutonium. While the charges are subject to change, it is the Commission's intention to keep them as stable as possible. In the United States uranium-235, uranium-233 and plutonium may be owned only by the Government, and may be made available for private uses only on a lease basis. The annual lease charge will be 4 per cent of the basic charge. These nuclear materials may be either sold or leased to foreign governments, and are available to those governments having agreements for co-operation with the United States. The charges announced will also apply to material distributed abroad. Research and development on uranium-233 and plutonium are generally in connexion with their use as reactor fuels. For this reason the charges are set at levels representing the fuel value of uranium-233 and plutonium as compared to existing charges for uranium-235, the material used as fuel in most reactors. The allotment for domestic civilian use totals 3·6 kgm. of uranium-233 and 37·5 kgm. of plutonium. Present allocations to domestic licensees amount to 0·04 kgm. of uranium-233 and 12·12 kgm. of plutonium, with applications for additional amounts pending. A study is in progress to determine what additional quantities should be made available for these purposes.

Pollution from Power Station Chimneys

When a wet fog lasts for many hours, the loss of heat by radiation into space from the top causes downward convection currents which stir the whole volume of the fog. At the top there is a sharp temperature inversion, the air immediately above the fog being warmer than the fog layer. Most pollution emitted within the fog remains within it, and if the fog is stagnant, the concentrations of smoke and sulphur dioxide may rise to dangerous magnitudes. It is therefore of the utmost importance to know whether the hot gases from a power-station chimney rise out of the top of the fog or are trapped below the inversion and contribute substantially to the accumulation of pollution below. Theoretically, the problem poses difficult questions which have not yet been overcome, and all theories are bound to make one or more assumptions which cannot be justified except by a long series of observations or experiments which have not yet been performed. The Central Electricity Generating Board has employed Fairey Air Surveys, Ltd., to fly over, and in, shallow London fog to measure temperatures and observe the behaviour of plumes from power stations along the Thames. The considerable navigational problems have been overcome, and on the morning of December 4 a flight was made and the plumes from three Thames-side stations were observed to rise into, and remain in, the air above the fog layer. The plumes from Brunswick Wharf Power Station were coloured red and black so that identification was certain, and photographs taken show that on this occasion the power stations did not contribute at all to the pollution at ground-level. There are undoubtedly circumstances of deeper fog and stronger inversions when the plumes would be contained in the fog layer. Further observations and experiments will be required before these circumstances can be specified with confidence; but it is clearly possible to build chimneys high enough and emitting gases hot enough for the gases to escape into the air above, and not contribute their quota of sulphur dioxide to the air we breathe at the ground when stagnant fogs occur.

Technological Education in India

Sir Willis Jackson, director of research and education, Metropolitan-Vickers Electrical Co., Ltd., has accepted an invitation from the Ministry of Scientific Research and Cultural Affairs of the Government of India to act as chairman of a committee, set up by the President of India, to review the work and progress of the first of the technology institutes in that country, namely, the Indian Institute of Technology, Kharagpur. The committee includes Shri D. L. Deshpande, director of the Bihar Institute of Technology; Dr. Atma Ram, director of the Central Glass and Ceramic Research Institute; Prof. M. Mujeeb, vice-chancellor of Jamia Millia Relamia, Okhla; Shri S. Ratnam, former finance secretary of the Government of India; and Shri G. N. Vaswani, assistant educational adviser (technical) of the Ministry, who will act as secretary.

Exchange of Students for Technical Experience

The eleventh annual report of the International Association for the Exchange of Students for Technical Experience (pp. 71. London: 1958) records in 1958, for the first time since the foundation of the Association, a decrease in the number of participants —from 5,934 in 1957 to 5,394 between 24 member countries. On the other hand, 2,777 industries, etc., participated, 436 universities and colleges, covering forty faculties, compared with 2,761 industries and 401 universities in 1957. Great Britain sent 774 students and received 784; for Sweden the corresponding figures were 359 and 736; France 343 and 410; Canada 24 and 95; Switzerland 151 and 202; Finland 175 and 202; and for Germany 998 and 1,023. Of those countries sending more students than they received, Austria sent 562 and accepted 308; Yugoslavia 220 and 116; the Netherlands 446 and 370; Turkey 232 and 166; Spain 244 and 207; Italy 177 and 153; and Israel 97 and 60. A special evaluation made by Great Britain on the basis of 4,249 reports on students since 1949 is to be published shortly, and the Association believes that, so far as the exchange can be evaluated with statistics, it has proved an undoubted success.

Scholarships in Mathematics for Courses in Statistics and Computational Methods

The London School of Economics and Political Science is developing courses in statistics and computational methods within the general framework of the degrees in economics of the University of London. The object of the new arrangements is to equip graduates with specialized knowledge in certain mathematical subjects and a general appreciation of the wider field of economics including accounting. A number of industrial and commercial undertakings have promised generous support to enable the School to provide the technical equipment necessary for the proposed course of study. It has also enabled the foundation of scholarships tenable in connexion with the new course. Each scholarship will be worth £450 a year and will normally be tenable for three years. Awards will be made without regard to the income of the parents or guardians of the successful candidates. For the academic year beginning in October 1959, two scholarships will be available. Further information can be obtained from the Registrar, London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2. Completed applications should be returned to the Registrar not later than January 31.

Interdisciplinary Conference on Self-Organizing Systems

An Interdisciplinary Conference on Self-Organizing Systems will be held on May 5 and 6 at the Museum of Science and Industry, Chicago, Illinois. The conference is to be co-sponsored by the Information Systems Branch of the Office of Naval Research and the Armour Research Foundation. The purpose of this conference is to bring together research workers in all fields of science who are concerned either with the development of self-adaptive information systems or with the conduct of research which may contribute to an improved understanding of cognitive, learning, and growth processes. Particular emphasis will be placed on theoretical models of systems which are capable of spontaneous classification, identification and symbolization of their inputs. Further information can be obtained from Mr. Scott Cameron, Conference Secretary, Armour Research Foundation, 10 West 35th Street, Chicago 16, Illinois.

Centenary of the Royal Society of Victoria

To mark the publication of Darwin's "Origin of Species" in November 1859, and the granting in the same month of the royal title to the Royal Society of Victoria, Australia, this Society will hold a symposium on "The Evolution of Living Organisms" during December 7–11, 1959. Dr. Ernst Mayr, of the United States, will be the principal speaker, and the symposium will open with a Tiegs Memorial Lecture in memory of Prof. O. W. Tiegs.

University News: Belfast

The following appointments have recently been made in The Queen's University of Belfast: G. C. R. Carey, to a lectureship in preventive medicine; Dr. G. S. Higginson, to a supernumerary lectureship in physics.

London

The title of reader in the University of London has been conferred on Dr. D. D. Davies (in plant biochemistry) in respect of his post at King's College; and on Dr. J. L. Mongar (in chemical pharmacology) in respect of his post at University College.

Pittsburgh

Thirty-two grants totalling 630,766 dollars have been awarded to the Division of the Natural Sciences of the University of Pittsburgh, Pennsylvania. Among the principal grants received since July 1, 1958, by six departments of the Division and the Radiation Laboratory are the following: 75,000 dollars to R. A. McConnell (assistant research professor, Department of Biophysics), from the A. W. Mellon Educational and Charitable Trust to continue research on psychological physics; 23,000 dollars to Dr. G. Felsenfeld (assistant professor, Department of Biophysics), from the National Science Foundation to initiate research on the active site in some copper-carrying proteins; 25,421 dollars to Prof. W. E. Wallace (Department of Chemistry), from the U.S. Atomic Energy Commission to continue an investigation of the application of chemical thermodynamics to study the formation of metallic alloys; 41,600 dollars to Dr. T. M. Donahue (associate professor, Department of Physics), from the Office of Naval Research to continue studies on capture-loss and ionization cross-sections of ions and neutral particles; 40,360 dollars to Prof. G. J. Wischner (Department of Psychology), from the National Institute of Mental Health to continue graduate training in clinical psychology; 129,000 dollars to Prof. A. J. Allen (director of the Radiation Laboratory), from the Office of Naval Research to continue research on precision scattering of nuclear particles; 38,415 dollars to Prof. G. A. Jeffrey (Radiation Laboratory), from the Air Force Office of Scientific Research to initiate research on the structure of crystalline hydrates of organic molecules and ions; 27,243 dollars to Prof. L. A. Page (Radiation Laboratory), from the U.S. Army Office of Ordnance Research to begin a research programme on low-energy nuclear and electron physics.

Announcements

Prof. Chien-Shiung Wu, professor of physics in Columbia University, New York, is to be awarded the 1958 Research Corporation Award for her valuable contribution to the knowledge of beta-decay and particularly for her part in research which resulted in the overthrow of the conservation of parity. She will receive an honorarium of 2,500 dollars, a plaque and a citation.

The following have been appointed to fill vacancies on the University Grants Committee: Dr. Kitty Anderson, head mistress, North London Collegiate School; Prof. Asa Briggs, professor of modern history, University of Leeds; Prof. F. A. Vick, professor of physics, University College of North Staffordshire; Dr. K. C. Wheare, rector of Exeter College, Oxford.

The symposium on "The Nature of Coal" organized by the Central Fuel Research Institute, India, will now be held during February 7–9, instead of during February 9–11, as was announced earlier (see *Nature*, 182, 295; 1958).

Between January 13 and March 17, the Department of Chemistry, Biology and Geology of the Kingston Technical College is holding a postgraduate lecture course on "Recent Advances in Protein Chemistry", with lecturers well known for their work in this field. Further information can be obtained from the Head of the Department at the Kingston Technical College, Fassett Road, Kingston-upon-Thames.

On February 6 the Scottish Branch of Aslib will hold its annual general meeting and conference in Glasgow. The theme of the morning session is patents, and that of the afternoon, mutual co-operation. The morning speakers will be Mr. Felix Liebesny on "Patents as Sources of Information", and Mr. Christopher Johnson on "Trade Marks and Industrial Designs, their History, Development and Protection". The afternoon speakers will be Mr. E. Martindale, of the Department of Scientific and Industrial Research, who will speak on the Scottish Research Laboratories Mutual Assistance Scheme, and, it is hoped, Prof. Christopher Macrae, from the Regional Technical Liaison Service of the Department.

In the communication entitled "Thermal Annealing of Chemical Radiation Damage" by Dr. A. G. Maddock and S. R. Mohanty in *Nature* of December 27, p. 1797, the graph refers to isothermal annealing at 150° C.

INDUSTRY AND THE INDIVIDUAL

THERE has been at least one remarkable change in British industry since the Second World War: that is the changed attitude towards the individual. Thirty years ago those discharged because of shortage of work were given short shrift; to-day, those unfortunate enough to be declared redundant are treated, in general, as individuals deserving sympathy, encouragement and help until they can become re-established.

To bring about this change in attitude has been one of the major pre-occupations of the Institute of Personnel Management, the membership of which has grown steadily in quantity and quality since the War. At Harrogate during October 10–12, the Institute held its most successful annual conference, which was attended by more than nine hundred representatives drawn from industrial organizations throughout the world.

The opening speaker was Sir Walter Puckey, chairman of Management Selection, Ltd., who argued that, of the many major industrial problems confronting us to-day, the four most pertinent are: the development of new 'machine' technologies; the development of new 'man' technologies; the development of men in the new machine age; the responsibility of the individual to the group and the group to society.

The State, backed by modern industry, is sponsoring more research per head per year than can be used economically, accepted socially, or desired militarily. This technological pressure is creating other pressures and problems, such as the financing of new projects, the need to double the numbers of technologists in ten years, the desirability of introducing more science into education, the greater need to humanize science, and the need to produce better political understanding in the face of a nuclear technological threat. Great success will attend those who encourage more laymen, arts men, workers, managers and scientists themselves to learn more of science and technology and so gaze with stimulated imagination and curiosity over the wider vista beyond.

Man is starting on a scientific exploration of himself, and recent years have seen an accelerated programme of research in physiology, psychology, neurology and sociology. Many leading industrialists are now convinced that an important field of research exists into individual man himself and his group relationships.

The better group objectives are organized the more likely is one to satisfy individual men within the group, but one should never be so committed to scientific method that one works towards, or desires, complete conformity. The better group management is, the more time and opportunity should be given to exceptional people and problems, remembering that while most men will conform most of the time, every man can and should be exceptional some of the time.

The development of social sciences and technologies is very important, but the greater use of the scientific approach to man and man-management will require better personnel management.

Thousands of skilled managers and millions of sensible workers have established in Britain a reasonable understanding with the machines of the first Industrial Revolution. We now have to establish a modified machine/man relationship in the second Industrial Revolution, where the machine will be more a machine of the brain than of the muscle. The brain machines may influence different groups of men, and their reactions may be even more critical than those of men in the first machine age.

The new machines will demand special skills which will be developed in, and used more by, the controlling or supervisory section of the working force. There has been a great invasion of offices by machines, and this will continue. We have seen the beginning of the impact of new machines and systems on control and communication activities, and their effect on organizational principles and practices. Since its birth, personnel management has been more concerned with blue or brown overalls than with white. The future may see a changing emphasis, with no less troubles in the first category but with added troubles in the second.

One important gap in the current research programmes will be filled when greater attention is paid to the problems of organizing men in the new machine environment. The installation and possibilities of a computer, for example, show how modern man can meet modern machines in a new and better relationship. There are far too many frustrations arising from poor organizational practices, and organization urgently calls for a more scientific approach. One way of judging a manager's effectiveness is his ability to delegate to other men. In the second Industrial Revolution one can also add his capacity to delegate to machines; this new man/machine delegation can create quite new organizational possibilities and problems.

The individual in the group and the group in society present two separate yet complementary problems. Individual recognition has been accorded to an increasing extent, from the level of Sir Winston Churchill to the growing number of occasions where individuality is recognized by placing names on badges at conferences, on desk signs in banks, stations, hotels and personnel offices.

Every indication of greater group power seems to be balanced by equal and opposite individual recognition. Currently, the technological developments in nuclear energy and automation are examples of this balancing factor.

As much attention has been given to human problems of safety in a nuclear age, and personal problems of living in an electronic brain age, as to the new technical problems themselves. It is significant that more books and major articles have been written on the Dead Sea Scrolls than on automation.

The problem of responsibility and efficiency in a nationalized industry was examined by Sir Harold Smith, chairman of the Gas Council.

The structure established by the Gas Act (1948) led to the setting up of twelve autonomous area boards. These are independent bodies for finance and tariffs, and are charged with the duties of developing and maintaining an efficient, co-ordinated and economical system of gas supply, and meeting, where economically possible, all reasonable demands for gas. The Gas Act also established the Gas Council, of which each area board chairman is a member. The Gas Council has a largely advisory relationship, not only with the Minister but also with each area board, and is charged with four specific duties relating to finance, research, training and education and industrial relations.

Through their association on the Gas Council, area boards are able to pool their specialized knowledge, skill and experience. As an example, research into the high-pressure gasification of small coals carried out at Solihull is to be developed commercially by the North Western Gas Board for the benefit of the whole industry.

In a public service industry, which has to maintain a continuous supply, it is essential to avoid stoppages through industrial disputes. There never has been a serious stoppage in supply. This is due to the co-operation of both employers and employees, fostered by the system of industrial relations in the industry. Both the employers and the trade unions concerned made an immediate response to the recommendations of the Whitley Committee, and the National Joint Industrial Council for the Gas Industry, together with its Regional (later Area) Joint Industrial Councils, dates from 1919.

The National Joint Industrial Council is still in existence, and the tradition of collective bargaining within the industry has been gradually extended by the creation of negotiating machinery to cover clerical staff, maintenance craftsmen, building trade workers, and ultimately all remaining groups of employees.

The statutory obligations imposed on the Gas Council and area boards, so far as industrial relations were concerned, were met largely by continuing the pre-vesting organization.

Joint consultation was encouraged in the industry before nationalization, and the National Joint Industrial Council had worked out a model constitution for works committees. The trade unions promised their support for the establishment of joint consultative committees at a joint conference on efficiency held in 1953, and such committees are now widely spread throughout the industry.

Improved efficiency since nationalization is shown by the use of fewer tons of coal to produce the same output. Additional costs including heavy capital charges have not been met by correspondingly increased revenue, the difference being absorbed by integration and higher efficiency.

Efficient organization is created largely through the individual efforts of its members. In the gas industry, the traditionally good industrial relations, and the emphasis on decentralization, encourage full participation by all employees.

The role of the trade unionist in relation to productivity and the rights of the individual were considered by W. J. Carron, president of the Amalgamated Engineering Union, who suggested that, although there have been isolated examples of 'go-slow' and other forms of direct action which have brought about alterations in the tempo and a retarding of productivity, ranging from restricted output, or service, to the extreme limit of total stoppage, at no time has trade unionism opposed or sought to obstruct productivity. The 'strike', the 'go-slow', the 'working to rule', or the 'overtime embargo' is merely the outcome of dissatisfaction with conditions of employment, a defence of the rights of an individual or group of individuals.

What are the rights of an individual when examined through the eyes of an industrialist as distinct from the objective approach of a social reformer ? It is difficult to segregate these two lines of theory because our social lives are inextricably interwoven with our industrial existence. The 'rights' of a modern worker in industry are not really 'rights' at all. They are mostly compulsory regulations laid down in the Factory Acts and similar statutory requirements which govern the employment of work-people. The remainder are to be found in agreements between trade unions and employers' organizations, both of which maintain a jealous watchfulness over the permissive and non-permissive clauses contained therein.

The formal establishment of an industrial 'right' dispossesses the individual in so far as that 'right' becomes the property of the nation or, to a less degree, of the particular pressure group that has succeeded in forcing its acceptance. The 'right' then stands every chance of becoming a 'must' and the individual has gained an industrial victory at the expense of industrial freedom.

There is no inconsistency in the desire of trade unions and trade unionists to make the closed shop more effective.

In highly complex industrialized societies it is necessary that certain personal freedoms must be limited to provide the greatest good for the greatest number. The character of our industrial pattern is such that there would be extreme difficulty in operating in a highly industrialized society without collective bargaining. For the maintenance of standards consistent with the rights of human beings it has been shown that trade unions are a necessary part of an advanced society. There is a distinct and direct charge upon individuals to sustain those institutions which provide not only for their welfare but for their existence. It is morally wrong that individuals should obtain both directly and indirectly the benefit of trade unions while completely evading their obligations.

There is an obligation upon employers to take some interest in this question. The theory by employers that membership of trade unions is no business of theirs is an outmoded thought and an evasion of responsibilities.

The trade unions are constantly faced with the problem of what will happen to the people displaced if completely automated forms of production become more widely adopted.

The major right of work-people in a time of technological change is security through continued employment.

All other demands of work-people are conditional upon the fundamental requirement of employment and fair wages. Among them is the strong ambition to have some voice in the practical administration of the aims and purpose of the employing organization.

During the War, production committees were formed ; many have disappeared. Much could be done to expand the nature and the beneficial influence of such committees, to create a greater understanding of the difficulties and mutual problems affecting both sides of worker/management relationship.

As workers and citizens, trade unionists demand the right to industries equipped with modern methods of applied technology in production at least commensurate with those of international competitors. Trade unionists also demand the right to produce adequately trained personnel, who are able to justify the setting up of this modernized equipment. Trade unionists demand the right to see industries linked firmly and securely to universities, not only in terms of technical education but also for industrial research. The right of an individual to expect advances in his living standards, or even to expect to maintain them at their present level, must depend upon his willingness to co-operate in productivity.

Besides the main addresses at the Conference a number of sectional meetings were held to discuss topics like the closed shop, the development of sandwich courses, liberal education and technical training, the recruitment and training of young workers and the cost and changing place of fringe benefits in salary and wage agreements. The latter was addressed by J. Simons, a director of the Package Sealing Co. (Export) Ltd., who showed how the term 'fringe benefits' is one that has crept into industrial jargon in recent years to describe all those items other than hard cash in the pay packet which are of tangible value to employees, whether they cost real money or not to the employer. Two main factors which have brought about this situation are: the influence of taxation on earnings, and competition for labour in the period of full employment that has existed since the War. The first factor has had particular effect on the value of benefits attached to appointments at high executive level where tax becomes heavy. At these levels the provision of supplementary or 'top hat' pension schemes, substantial life assurance, education grants, and even the provision of housing, become important items in the total assessment. The second factor, competition for labour, accounts for the fact that initiative to add to fringe benefits has tended to come from management, rather than from trade unions, though the latter have brought pressure to bear on a number of factors, particularly holidays with pay, compensation for redundancy, guaranteed work-week, and in more recent years, pensions.

Though the provision of fringe benefits has grown in the past twenty years, it is still seldom that one finds them mentioned specifically in employment agreements as part of the contract of employment, even for executive appointments, and still less at operative-levels. Items within the field of fringe benefits are beginning to feature more and more in negotiated agreements between unions and selected industries.

In examining the costs of fringe benefits a number of aspects have to be considered. No clear picture has yet emerged on the correlation between the size of the company and the cash value per employee of the benefits provided; there is, however, some indication that the larger the industrial unit the greater is the range—and hence the cost per employee—of the benefits available.

One survey covered some sixty companies of varying size. It directed attention to the wide variation in the cost of certain items (pension, sick pay, life insurance, canteen subsidies and travelling allowances). For these items, the variation in cost among the companies covered by the survey was as follows:

Percentage of companies covered by the survey	Cost of all fringe benefits as per cent of total pay-roll
9	under 2½
14	2½–5
28	5–10
18	10–20
12	20–30
3	over 30
16	not disclosed

A more recent survey covering some fifty companies showed that the total cost of benefits varies between 12 and 25 per cent of the total employee remuneration —the median being just under 15 per cent.

In those cases where the cost is high, the biggest single item is usually pension contributions; it is here that many companies could secure better value for their money than they do. Those concerns that have made a close study of the provision of pensions, and have established internal funds with wide investment powers, are better placed to keep pace with inflation than those with insured schemes, and usually at lower cost.

The way to control 'fringe benefit' costs might be to predetermine an overall cost factor expressed as a percentage of the pay-roll, and from the proceeds to cover the costs of those benefits which the company, as a matter of good business policy, would wish to provide, leaving the residue to be used on additional benefits of the employees' own choice. It would have the merit of creating in the minds of both employers and employees a greater awareness that the provision of benefits costs money and that such costs require to be controlled. Such an arrangement would have the merit of controlling the costs of benefits in the simplest possible way; it would take them out of the realm of miscellaneous overheads and enable them to be treated as a definite cost item in the same way as wages and salaries.

MEASUREMENT AND CONTROL IN ELECTRICAL ENGINEERING

THE ever-widening interests and knowledge of electrical engineers as a body have their effects on the organization and division of the activities of the Institution of Electrical Engineers. Originally founded as the Society of Telegraph Engineers in 1871, it soon became necessary to indicate its wider interests by a change of name, first to the Society of Telegraph Engineers and Electricians in 1880 and then in 1888 to the Institution of Electrical Engineers.

Later it became necessary to make administrative provision for the presentation of specialist papers, and the Meter and Instrument Section came into being in 1928. Like its parent body, the interests of this specialized Section widened year by year, and its name was changed first to the Measurement Section and later to the Measurement and Control Section.

The most recent change is the institution of five panels concerned with particular aspects of the activities of this Section. Mr. J. K. Webb, in his address as chairman of the Section, delivered at the Institution on October 4, has most appropriately directed attention to recent technical advances in the branches of knowledge covered by the separate panels.

The first panel is concerned with fundamentals, standards and laboratory measurements, and Mr. Webb pays his tribute to the M.K.S. system while skilfully avoiding the more controversial aspects of the subject. The accuracy of definition of the fundamental units of mass, length and time has now been brought to about one part in 10^9 for mass, one part in 10^8 for length and one part in 10^{11} or better for time. Enthusiasts for new systems of units who favour a single arbitrary standard in place of the present three will have no difficulty in selecting time for this purpose.

The accuracy of establishment of the electrical units is perhaps somewhat disappointing, being about 1,000 times worse than the lowest accuracy of the fundamental units. It is therefore interesting that consideration should be given to the possibility of establishing a calculable standard of capacitance. To obtain an improvement in the establishment of electrical units by this method, it will be necessary to measure a capacitance of the order of 1 $\mu\mu$F. to an accuracy of 1 $\mu\mu\mu$F.—no mean feat of measurement.

The second panel is concerned with materials and components and there can be little doubt that Mr. Webb was justified in selecting, as the feature of greatest interest at the present time, the commercial production of germanium and silicon with impurity contents of less than one part in 10^8.

Measuring techniques, devices and instruments are covered by the third panel. This is a wide field where choice would be difficult. However, electrical joints occur in most electrical apparatus, sometimes in very great numbers.

The soldered joint made by a skilled operative has been long established and is still of great value, but occasionally a dry joint is obtained which may give trouble. Wrapped joints have now been developed, with a life expectancy of forty years, which can be made by unskilled operatives at great speed. The bound joint is an interesting variant in which wires of various diameters are bound together with binding wire of fixed diameter. This should simplify the design of wrapping tools.

The fourth panel is concerned with data processing, including analogue and digital computers. A vital component of the computer is the memory, which is often either a magnetic tape, a magnetic drum or a large number of magnetic elements such as ferrite toroids or straight magnetic wires.

The latest development involves the trapping of magnetic flux in a superconductor. This method holds out the hope of providing an access time about 1,000 times less than the fastest of the magnetic devices, but as the necessary equipment includes a helium liquefier the capital and operating costs of the memory may prove to be very high.

The fifth panel covers servo-mechanisms and control systems, a subject of some antiquity but one in which recent developments have occurred at a great rate.

The sensitivity and speed of response of modern servo-mechanisms are aptly illustrated by the possibility of controlling a magnetic field so that a piece of iron is held stationary between the upward pull of the field and the downward pull of gravity. Satisfactory damping has been achieved for this device.

A useful list of references is an unusual addition to a chairman's address, making it possible for the interested reader to go deeper into any subject of special interest to him.

A. H. M. ARNOLD

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, NEW ZEALAND

ANNUAL REPORT

THE annual report* for the year ended March 31, 1958, of the Department of Scientific and Industrial Research, New Zealand, includes the usual statement by the Minister, the brief report of the Council and the longer report of the Secretary, together with reports from the branches and incorporated research associations. Some notes are included on grant-aided research at Canterbury Agricultural College, the Cawthron Institute, Massey Agricultural College and the University of Canterbury Industrial Development Department. Lists of publications are appended to the various departmental reports. Substantial effort was again devoted to the work of the International Geophysical Year, and a senior officer of the Department visited the New Zealand territories in the Pacific Islands to assess the agricultural problems to be solved if production is to meet the requirements of growing populations and satisfy the need for modern services and amenities.

Expenditure in 1957–58 was £1,535,000 gross, compared with £1,404,000 in 1956–57, the latter figure being 0·137 per cent of the national product. The Council believes that the future development of New Zealand depends very materially on scientific research and development, and urges that the percentage of national income should be increasing and not decreasing: during 1949–50 it was 0·173 per cent of the national product, and during 1951–52, 0·152 per cent. The professional staff of the Department at March 31, 1958, was 383, compared with 369 in the previous year, but was nineteen fewer than six years previously. In particular, the need to increase the work in nuclear science carried out by the Division of Nuclear Sciences and by the universities is emphasized, and the Council, after considering the position, envisages expenditure of some £500,000 to install and operate equipment to meet New Zealand's needs. Grants to research and allied institutions totalled £141,031, including £30,000 to universities and colleges of agriculture, and the Council is also concerned to extend the assistance at present given to industry.

The Secretary's report is mainly concerned with research completed during the year and includes a fairly full summary of the scientific activity in the Ross Dependency and in connexion with the International Geophysical Year. Scientific assistance given to the Police Department has included the use of paper chromatography for the separation and identification of barbiturates. The Philips electron microscope was installed at the Dominion Physical Laboratory in April 1958. The radiocarbon technique has been used to examine an ocean profile from the New Caledonian Trench, and preliminary investigations indicate that the method can also be used to study the circulation time and direction of underground water flow at Wairakei, while a theoretical study has been made of a possible way of extending the range of the carbon-14 dating equipment by isotopic enrichment using a thermal diffusion column. The sulphur isotopic variations in the sulphide and sulphate of geothermal bore waters have been used to estimate a temperature of 370 ± 70° C. for the hot chloride water underlying Wairakei.

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* Report of the Department of Scientific and Industrial Research for the year ended 31 March, 1958. Pp. 90 (H.34.) (Wellington, Government Printer, 1958.)

Surveys over twelve years of areas susceptible to grass grub indicated that none of the land sown in introduced pastures and crops is absolutely free from grub attack, and as the texture of the soil improved, the land became more liable to attack. Grass grubs may be the main cause of weed encroachment on pasture lands, and the satisfactory control of grass grub in both North and South Islands has shown that pastures protected with DDT do not become infested with weeds. The decreased effectiveness in the past three years of the scale insect, *Eriococcus ovariensis*, as a controlling factor on manuka in the northern Hawke's Bay area appears to be due to the presence of a parasitic fungus capable of killing the scale insect responsible for manuka blight. An insect survey of agricultural crops in New Zealand was initiated, and a preliminary survey of grasslands in the North Island has already yielded much information on the distribution and relative abundance of more than 270 species of insects. Trials on rape selected for resistance to aphids proved as productive, or more productive, than the Broad Leaf Essex strain, and still grew well under aphis infestation sufficient to destroy the latter. Field trials by the Plant Diseases Division indicated that a recently introduced variety of swede, Doon Spartan, is comparable to the New Zealand bred variety, Calder, in resistance both to virus and to the cabbage aphid, but that the varieties resistant to cabbage aphid are not necessarily resistant to other aphids.

Research into the fundamental cause of bloat or tympanites of cattle indicates that the disorder is a very complex problem in plant–animal interrelations, and the various aspects of animal physiology, microbial metabolism and plant biochemistry involved are now being investigated. In grassland research an improved strain of *Lotus uliginosus* is under trial, but although more vigorous than those strains obtainable commercially, it is still slow to establish from seed, and work is in hand to improve the winter productivity. Work continued on the soil fertility cycle and the various aspects of fertility increase under pasture, fertilizer and the grazing animal and the decrease under different forage and food crops, and a study of seedling growth. Recent work by the Plant Diseases Division has shown that the death of pines in shelter belts is associated with the presence of *Phytophthora* species in the soil, and in connexion with this investigation the Auckland Industrial Development Laboratories have developed a method of measuring flow of sap by means of heat transport.

A survey of phosphorus in New Zealand soils has indicated the factors which determine the amount and nature of phosphorus in the soils, and, in turn, a better understanding of their requirements of phosphatic fertilizers. The survey has shown the dominating influence of soil processes in determining these requirements. The general soil survey of the South Island was used as a basis for constructing a map of the present utilization and possible development of land in the Otago district.

Discovery of a method of separating apple cells without altering their shape or size has considerably assisted the Fruit Research Division's measurement of cell size in Sturmer apples after different fertilizer treatments with a view of forecasting storage quality, and to meet the need of the stone-fruit industry for good descriptions the Division has started to sort out some sixty varieties of Japanese plums. 'Vapan' and allyl alcohol have given promising results for control of weeds in tobacco seedling beds, but the former must be used at least four weeks before the seed is sown, and excellent control of both types of stem rot was obtained by applying a drench of ferban or thiuram to the seedling beds. Investigations at the Cawthron Institute show that shade and high humidity are factors in the development of blotchy ripening, a physiological disease of tomatoes, and preliminary results at the Dominion Physical Laboratory indicate that the critical stage of fruit development is when the fruit is fully developed and just beginning to ripen. Observations have also been made on the rate at which rabbits recolonize an area, following complete destruction of the population.

ELECTRICAL DISCHARGES

THE Physical Society autumn conference on "Gas Discharges" was held at the University College of Swansea during September 17–20. The wide interest in this field of study was shown by the presence of some 200 delegates, including many from Australia, Germany, Norway and the United States. At the five sessions of the conference more than thirty papers from Government, industrial and university research laboratories were read. The present report is restricted to a brief description of a representative selection, grouped in accordance with subject-matter.

The conference was opened and the first session presided over by J. A. Ratcliffe (Cambridge), president of the Physical Society. The inaugural address was given by Prof. H. S. W. Massey (University College, London) and was devoted to a comprehensive review of recent experimental and theoretical advances in the study of atomic collisional phenomena, particular attention being paid to cross-sections for collisions of electrons with atomic hydrogen, on which a reliable body of theoretical knowledge now exists. The experimental method being used at University College, London, in which a modulated beam of atomic hydrogen is crossed by an electron beam and the resultant ionization analysed by a mass spectrometer, was described, later, by Dr. R. L. F. Boyd and A. Boksenberg (University College, London).

Other topics discussed in the inaugural address included the experimental verification in the U.S.S.R. and in the United States of the existence of a negative metastable ion of helium, previously predicted on theoretical grounds by two Norwegian investigators, and other results of recent work on negative ions. Of particular interest were the facts that the electron affinity of O^- has now been established as 1·45 eV., and that the cross-section for the production of I_2^- by slow electrons has been found experimentally to be surprisingly large ($\sim 3 \times 10^{-15}$ cm.^{2} for low-energy electrons).

Fundamental Processes

In an invited paper on "Investigation of the Secondary Processes in the Townsend and Streamer Regime", Prof. H. Raether (Hamburg) described oscillographic studies on the temporal growth of ionization in Townsend avalanches, and showed that values of the primary ionization coefficient α and the electron and ion mobilities may be obtained in this way. He also discussed studies under conditions in which the secondary ionization coefficient was so low (for example, in methane) that the primary amplification $e^{\alpha d}$ could attain very large values of the order of 10^8, and appeared to promote rapid breakdown originating from a single avalanche.

Prof. F. Llewellyn Jones welcomed the conference on behalf of the Department of Physics, University College, Swansea, and gave a short introductory account of recent work by the Swansea group. He stressed that with the mathematical treatment of ionized gases available to-day, only precision measurements can lead to the required data about fundamental ionization processes. Such significant measurements of, for example, ionization coefficients or of rapid current-growth can be made only when the state of purity of the gas and electrode surface is controlled; when the precise state of a cathode surface is unknown (because of the presence, say, of a thin film) the surface may still be specified by measuring its effective work function. Some recent results obtained with parameters thus controlled were described in the following papers.

From measurements of the temporal growth of ionization, Dr. E. Jones (Swansea) showed that with field stabilization and controlled conditions of electrode surface and purity of gas, 'scatter' of measurements was eliminated to give consistent values of formative time-lags, from which the individual secondary ionization coefficients (γ and δ/α) in hydrogen at pressures less than 10 cm. mercury were accurately deduced. The dependence of these coefficients on the work function of the cathode surface was also determined. Dr. J. Dutton (Swansea) reported recent precision measurements in hydrogen at high pressure of the secondary ionization coefficient, showing that this coefficient is a function of the gas pressure. It follows that the fundamental secondary process (ω/α) consists mainly of the cathode photo-emission produced by molecules excited in the avalanche, but that some excited molecules are destroyed by collisions of the second kind before they are able to radiate. Theoretical calculations of ω/α using known data for atomic cross-sections agree with the values measured.

Another paper dealing with measured work functions was read by Dr. E. Davies (North Staffordshire), who described the influence of work function in the range 2·0–4·5 eV. on the sparking potential in hydrogen at low pressures.

Measurements of pre-breakdown ionization currents in a range of pressures from 60 mm. mercury up to atmospheric pressure, which indicate the presence of considerable attachment ($\eta/p \sim 5 \times 10^{-3}$) for values of E/p from 25 to 45 V./cm. mm. mercury, were described by A. N. Prasad (University of Liverpool). Other recent work at Liverpool was described by M. C. Sexton, who discussed micro-wave studies on recombination and attachment in the afterglow of rare gases and oxygen, and by Prof. J. D. Craggs, who discussed the effect of electrons on the broadening of the Balmer lines. From measurements of the intensity of the Balmer continuum and its variation with time, values of the electron density and temperature were obtained, and using known values of the radiative recombination coefficients, the broadening effect of electrons was calculated.

Arc Discharges

An invited paper by Prof. J. M. Somerville (New England, Australia) described the study of anode marks made by an arc channel during the early stages of growth, from 20 mμsec. to 200 μsec. For pulses less than about 10 μsec. multiple spots were formed inside a circular area, the size of which increased for pulses up to 100 mμsec.; for longer pulses this area remained constant but the individual spots themselves grew bigger and finally coalesced. By considering the energy balance in the bright glow adjacent to cathode spots, M. A. Cayless (British Thomson-Houston, Rugby) deduced the factors governing the shape and size of the glow and the electron and ion currents at the cathode surface. Measurements, by Dr. H. Edels (Liverpool), of the gas temperature using shock-wave measuring techniques at varying times after the interruption of a low-current arc indicated thermal time-constants of about 500 msec. Dr. A. E. Guile and P. E. Secker (Queen Mary College, London) showed that the forward continuous motion of an arc cathode spot in a transverse magnetic field in air at atmospheric pressures is controlled by cathode surface conditions, velocity of motion being independent of the arc current between 40 and 700 amp. Using colour slides, L. A. King (Electrical Research Association, Leatherhead) discussed the jets observed in the high-current electric arc on the basis of a theory of dissociation and ionization and showed that these jets account for the metal transported in the welding arc.

Transient Discharges

An interesting group of papers was concerned with the operation of Sceptre III in the laboratories of Associated Electrical Industries at Aldermaston. Dr. N. L. Allen and Dr. R. M. Payne first surveyed the experimental techniques employed and discussed the correlation of results obtained from oscillographic studies, rotating-mirror photographs, magnetic search coil and spectroscopic investigations; these investigations indicated that the discharge could be stabilized to a certain extent. J. A. Wesson and B. S. Liley then discussed the determination of the inductance of the discharge and outlined a method by which the distribution of current in, and the motion of, the discharge and the extent to which the plasma traps the magnetic field within itself could be obtained from these measurements. Finally, Dr. H. T. Miles described an investigation of the mechanism of initiation of parasitic arcs inside the torus and methods used in controlling them.

Another paper in a closely related field was given by Dr. W. G. Townsend (Swansea), who discussed the liberation of electrons from cold cathodes in gases under electric fields $\sim 10^5$ V./cm. The mechanism involved emission due to the enhanced field produced by positive ions on a thin cathode film; measurements of electron liberation at 300° K. and 600° K. showed that the dependence on temperature was too small to be accounted for by local thermionic emission.

Recent work at the Atomic Weapons Research Establishment, Aldermaston, on shock waves from electrodeless discharges was described by G. B. F. Niblett. Interesting streak photographs of the luminosity produced by strong shock waves obtained in argon, helium and deuterium at low pressures by discharging energy (about 1,000 joules) through a single-turn external coil were shown and analysed.

Spark, High-Frequency and Glow Discharges

In order to accommodate the large number of papers submitted, the final session was divided into two sections, running concurrently. One of these, which was devoted to spark, high-frequency and glow discharges, contained two papers by members of the group working under the direction of Prof. F. M. Bruce (Royal College of Science and Technology, Glasgow) on long (~ 5-cm.) uniform field gaps in air at atmospheric pressure. D. T. A. Blair (in a paper with Prof. F. M. Bruce and J. E. Matthews) described simultaneous recordings of light and current pulses in such gaps at voltages just below the breakdown potential, and A. Aked (in a paper with Prof. F. M. Bruce and C. Gordon) described the effect of various parameters, showing that air circulation gives a more reproducible breakdown potential in an enclosed spark gap.

The problems encountered in the application of discharge techniques to industrial conditions were clearly, and often amusingly, illustrated in a paper dealing with electrostatic precipitators by J. S. T. Looms (Central Electricity Research Laboratories, Leatherhead). It was shown how the leakage of air into the flue gas in such precipitators could lead to spark-over.

Other papers in this session were concerned with measurements of breakdown at high frequencies, radio-frequency conductivity in afterglows, breakdown and maintaining potentials in helium – neon mixtures, and the advantages of deuterium over hydrogen as a filling for thyratrons.

Collision Processes and Energy Distributions

The other section of the last session was devoted to collision processes and energy distributions. Dr. J. Thompson (University College, London) concluded, from a study of the energy distribution and concentration of electrons and the temperature and concentration of positive and negative ions in oxygen discharges, that the destruction process for negative ions involves oxygen atoms. Probe measurements in striated positive columns were discussed in a paper by N. D. Twiddy, of University College, London (read by Dr. R. L. F. Boyd), and the existence of two well-separated groups of electrons demonstrated. Theoretical computations of α for argon, helium and neon using an energy distribution function for electrons derived directly from the collision cross-section were discussed in a paper by Dr. A. E. D. Heylen and Dr. T. J. Lewis (Queen Mary College, London). The phenomena attributable to the excitation of hydrogen by electron swarms were shown by Dr. R. W. Lunt (University College, London) to be explicable in terms of the experimental data for mono-energetic beams and the recent predictions of wave-mechanical theory. L. R. Griffin (Swansea) gave results of relative excitation cross-sections in helium computed from the intensities of lines in the spectra from high-frequency glow discharges. A paper by K. Persson (General Electric Research Laboratories, Schenectady), who was unable to be present, was read by Prof. F. Llewellyn Jones. The paper assessed the microwave technique and reported recent measurements on high-density plasmas, showing that the method can be greatly extended by applying solenoidal probing fields on plasmas with rotational symmetry.

During the conference the delegates were welcomed on behalf of the University College of Swansea by the vice-principal at a reception given by the College. Another much-appreciated feature of the proceedings was an afternoon break halfway through the conference, when delegates were enabled to see something of either the industrial life of South Wales at the Abbey Works of the Steel Company of Wales, or the scenic beauty of the Gower Peninsula.

J. Dutton
E. Jones

THE GENUS *DAPHNIA*

Daphnia is a genus of freshwater Crustacea the systematic study of which presents many difficulties, although the number of species in the world is not particularly large. The greatest difficulty arises from the fact that many of the species are very variable in conspicuous characters, such as the shape of the head. All the specimens of a species collected at any one time and place are usually very similar to one another, but specimens collected in different bodies of water often show great differences and also may undergo a cyclical series of changes with the seasons of the year. The seasonal rhythm, known as cyclomorphosis, is followed only approximately in the laboratory, and Dr. J. L. Brooks's first study of *Daphnia* was an investigation at Yale of environmental factors concerned, in which his discovery of the importance of the turbulence of the water was new and of great interest. The unsatisfactory state of the systematics of *Daphnia* has hindered his further studies on the evolution of the genus, and his recent memoir* on the systematics of North American *Daphnia* is a result of his very successful attempt to remedy this for that part of the world which concerns him, and since many of the species are also found in Europe and elsewhere, his results are of world-wide interest.

The early workers erected a great many names before it was realized how variable a species of this genus could be, but for the past fifty years or more there has been a great tendency to lump these together, many of the old names being kept for the numerous 'varieties'. Dr. Brooks gives strong support to those who have suggested that the lumping has been excessive, especially with a long series of forms which were called *pulex* if a comb was present on the claw of the tail, or *longispina* if the comb was absent. In Europe, under this scheme, the planktonic *Daphnia* of lakes are all varieties of *longispina*, exhibiting great diversity of form and often with marked cyclomorphosis, and *pulex* is confined to small bodies of water; in North America, on the other hand, it is *pulex* forms that inhabit the Great Lakes and exhibit a great diversity of form. Dr. Brooks finds, however, that the true *Daphnia pulex* occurs in North America, but it is found in ponds as it is in Europe, and he assigns other names to most of the species in lakes. He also finds, rather surprisingly, that *Daphnia obtusa* and the true *D. longispina* do not occur in North America, though *D. rosea* does. The latter was thought to be merely a variety of *longispina*, but good evidence for treating it as a separate species is produced, and the applicability of the name for the American specimens is shown by a reproduction of some pencil drawings made of Sars's type specimens by Richard before 1896. It is very fortunate that specimens of Sars's type material of this species now in the British Museum, and which Dr. Brooks had not seen, agree fully with his description. The identification as *D. rosea* of specimens of *longispina* from England in his collections, and also his opinion that *D. hyalina* and *D. galatea* (both also *longispina*) are distinct species, will, if substantiated, lead to changes in the names of British and other European species of *Daphnia*.

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* Memoirs of the Connecticut Academy of Arts and Sciences, Vol. 13 (November 1957): The Systematics of North American Daphnia. by John Langdon Brooks. Pp. 180 (61 plates). (New Haven, Conn.: Connecticut Academy of Arts and Sciences, 1957. Obtainable also from Yale University Press.) 8 dollars.

In addition to extensive collections from most parts of North America, Dr. Brooks has made good use of the specimens, pencil drawings and other materials relating to the pioneer American workers, Forbes and Herrick, and also to the European authorities, Richard and Sars. This material has enabled him to find the correct names for the fifteen species which concern him from among names already published, in spite of the inadequacy by modern standards of the older original descriptions. To have found an appropriate name in each case, and to have been able to give his reasons clearly and convincingly, is a great tribute to his patience and skill. A lesser man would have invented a series of new names.

The bulk of the work is occupied by careful and very full descriptions of the fifteen species, with good line drawings and information on the geographical distribution and ecology. There is also a key to the species with the diagnostic characters figured at the side of the page, and an ingenious method of linking the drawings with the key. A separate part of the work is devoted to a discussion of ten separate regions of North America which the author has been able to distinguish on the basis of the distributions of the species, complex though these are.

Of particular interest in Britain is Dr. Brooks's discovery that *D. ambigua* is a widely spread North American species, for until now this species had been known only in England. It was first found in a pond in the Royal Botanic Gardens at Kew, and described by Scourfield in 1946, who suggested at the time that it had been introduced from abroad with aquatic plants.

This memoir whets the appetite for further publications in which an elaboration is promised of theoretical considerations, including the reasons for the author's belief in the adaptive significance of the extensive cyclomorphic variation in the genus *Daphnia*, which he suggests is the most interesting of the fruits of his study of their systematics.

J. P. Harding

A CLIMATOLOGICAL WIND TUNNEL

By Dr. P. E. WEATHERLEY and H. D. BARRS
University of Nottingham

In our studies of the water economy of plants it has proved necessary to subject as many as thirty large potted plants to known atmospheric conditions. For this purpose a wind-tunnel has been constructed at Nottingham which provides an air-stream of controlled speed, temperature and humidity. The control of these major atmospheric factors has been so successful that the details of the equipment may well be of interest in wider fields of research than those for which it was designed.

Our aim has been to control temperature, humidity and wind speed independently, thus making it possible to realize any one of a wide range of atmospheric conditions. Furthermore, it was not only necessary to hold any reasonable combination of temperature and humidity constant, but also to be able to change from one set of conditions to another fairly rapidly and even, if possible, to change conditions continuously and smoothly in a known way; in other words, to set a programme of climatic change. The equipment to be described fulfils these aims in large measure. The wind-speed can be varied between 2 and 16 ft./sec., the temperature between 10° and 40° C., and the relative humidity between 40 and 100 per cent at temperatures around 25° C., while at 35° C. a relative humidity as low as 25 per cent can be achieved.

In the first instance, no control of light has been attempted, natural light being used by constructing the working section of the tunnel of glass and erecting the tunnel in a glasshouse. Fig. 1 represents sections of the equipment seen from the side and end. The tunnel is of a closed-circuit type, and has a working compartment 12 ft. long, 3 ft. wide and 2½ ft. high, below which is a trough 14 in. deep for the pots. Thus, the pots are kept out of the main air-stream. This compartment consists of a wooden frame bearing glass panels, those forming the sides being fitted in felt-lined grooves to slide vertically and give access to the tunnel. The end sections and return duct underneath the working compartment are lined with tempered hardboard and have cavity walls for heat insulation.

The aerofoil fan *F* (Fig. 1) is belt-driven by an externally placed 4 h.p. d.c. motor connected to a Ward Leonard set giving speed regulation by voltage control. The air stream is deflected through two right angles by the guide veins *G*, through section *C* containing the sensitive elements of the control system, to the working compartment via the honeycomb *H*. This arrangement gives an even distribution of air-flow in the working compartment, no more than 5 per cent variation in wind-speed occurring across the tunnel. No guide veins are used at the

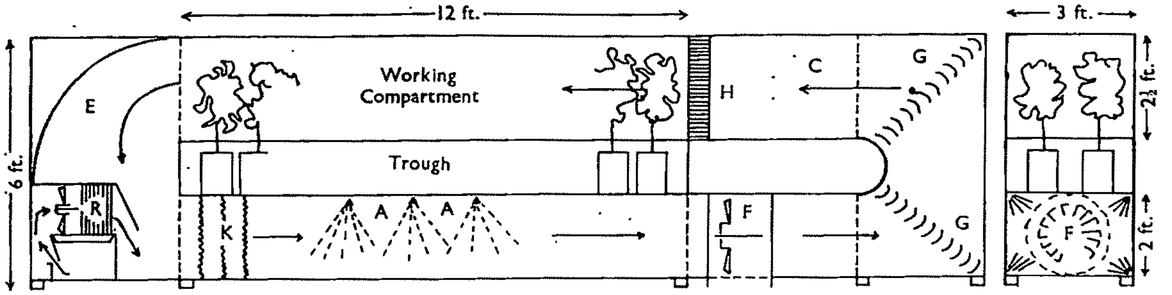

Fig. 1. Elevation diagrams of the tunnel viewed from the side and end

end *E*, since here turbulence is of little significance. The refrigerator *R* used both for cooling and drying the air is enclosed in a cabinet through which no air passes unless the refrigerator fan is in operation, when a part of the air-stream is drawn over the cooling coils. These coils are kept at a little above freezing point, and moisture condensing on them is collected on a tray beneath and drained to the exterior. The refrigerator compressor is situated outside the glasshouse. The heating elements *K* consist of bare coils strung across a frame and are arranged in three banks. One bank approximately balances the cooling effect of the refrigerator and is switched on automatically when the refrigerator is being used for dehumidifying the air-stream. A second bank is used for temperature control, and a third is manually operated to provide 'background' heating when the tunnel is operating at temperatures appreciably above ambient.

After passing over the heating elements the air-stream may be humidified by the atomizers *A*. These are operated from a compressed-air line and switched on and off by a magnetic valve.

Wind speed is set by adjusting the voltage of the d.c. supply to the fan motor, the voltmeter readings being calibrated in terms of wind-speed measured on an anemometer in the tunnel. Once set, the wind speed shows no detectable variation. The temperature and humidity control is of a simple 'on–off' pattern. The sensitive elements are resistance thermometers of platinum wire on mica formers unencased so that they are of low heat capacity and respond very rapidly to change of temperature. Each element forms part of a Wheatstone bridge circuit in which any unbalance due to a temperature-induced change in resistance of the element deflects a galvanometer. The position of the galvanometer needle whether at zero or to the left or right is automatically 'tested' every 10 sec. and according to its position the appropriate contactors are operated via mercury switches. Three resistance thermometers are used: one for temperature control and the remaining pair for humidity control on the principle of wet-bulb depression, one of the pair being draped in wet muslin, and the control operating on the difference in temperature between the wet and dry elements. The wet element is fitted with a small fan to ensure its adequate ventilation at low wind speeds. Each of the two bridge circuits with its galvanometer, synchronous motor, etc., is installed in a control box provided with a temperature scale and setting lever. In addition, each box can be fitted with a cam (of any desired shape), which alters the setting lever as it rotates and provides, instead of steady atmospheric conditions, a continuous change of temperature or humidity or both. This equipment is made up of standard commercial units and together with the specially designed resistance thermometers was supplied by the Foster Instrument Co., of Letchworth, Herts.

Operation of the control system is as follows. If the temperature in the tunnel falls below the set temperature, heating elements *K* are switched on (these can be varied between $\frac{1}{2}$ and 3 kW. and are set manually according to requirements). If the temperature rises above the setting, the refrigerator fan and compressor are switched on. Between these two there is a 'mid off' position having a range of 0·1° C., within which neither the refrigerator nor heaters operates. Similarly for humidity control, if the difference in temperature between the wet and dry elements is greater than the set value the atomizers are switched on. If the difference is less, the refrigerator fan, compressor and balancing heater are switched on. Here again there is a 'mid off' interval of 0·1° C. When cool, dry conditions are required, both the temperature and humidity controllers switch on the refrigerator, but in this event the balancing heater fails to operate and both a cooling and dehumidifying effect of the refrigerator is obtained. When cool, wet conditions are required, both the refrigerator and atomizers will operate, and here the humidifying effect of the latter must be sufficient to over-ride the dehumidifying effect of the former. This is merely a matter of having sufficient atomizers.

As yet the control of the tunnel is not entirely automatic. For precise control it is necessary to keep the 'on–off' heaters as small as possible, using a continuous background heater which would itself maintain the temperature at a little below the desired level. The power of this background heater depends on the difference between the desired level and that in the surrounding greenhouse. In the summer time the temperature of the greenhouse varied widely during the daytime, and this necessitated periodical manual adjustment of the background heaters. In fact, it would not be difficult to control these automatically in relation to the ambient temperature.

Ordinary meteorological thermographs and hygrographs have been used to record conditions in the working compartment. These are not necessarily reliable in recording the absolute levels of temperature and humidity under the conditions of violent change sometimes imposed upon them. But they are very sensitive to variations in conditions and respond rapidly; thus they are useful for testing the degree of control attainable. Absolute levels of temperature and relative humidity were checked using wet and dry bulb mercury thermometers. The instruments were shaded from direct sunlight.

The precision of control depends on the combination of temperature and humidity chosen and, of course, on the variation of temperature inside the glasshouse. A given temperature is usually maintained indefinitely within ± $\frac{1}{2}$° C. or better, and the relative humidity within ± 1 per cent or better. Examples of the performance of the control system are shown in Figs. 2 and 3. Stepwise changes in humidity at a constant temperature are shown in the upper part of Fig. 2. These were simply obtained by altering the humidity control setting from time to time. It will be noted that the change is effected rapidly; indeed, the humidity probably changed very quickly, the curves shown in the records representing the maximum speed of response of the hygrograph. The maintenance of constant humidity at various temperatures (Fig. 2, lower part) necessitated the adjustment of both the temperature and humidity controls at each step, the difference between the wet and dry bulb temperatures to give the same relative humidity at each temperature being obtained from tables. Deviations in relative humidity as much as ± 2 per cent occur during the change of temperature, but at each steady temperature the deviations are seldom more than ± 1 per cent.

As mentioned above, the control units could be fitted with programme cams giving continuous smooth adjustment of temperature and humidity. For a programme of changing humidity at constant temperature a cam is fitted to the humidity controller only. The result is shown in Fig. 3 (upper part). Varying temperature at constant humidity requires cams fitted to both temperature and humidity controllers; a typical result is shown in Fig. 3 (lower part). The cams in these two examples were eccentric circles giving sine curves of temperature or humidity, but asymmetrical cams or cams with fairly steep steps can be cut to give a wide variety of programmes. Also the speed of rotation of the cams can be varied within wide limits.

It should be emphasized that these results were obtained in a glasshouse often with intermittent sunlight and widely varying temperature. Fluorescent lighting is ultimately to be fitted around the outside of the working compartment and with this some control of the remaining major climatic factor should be achieved.

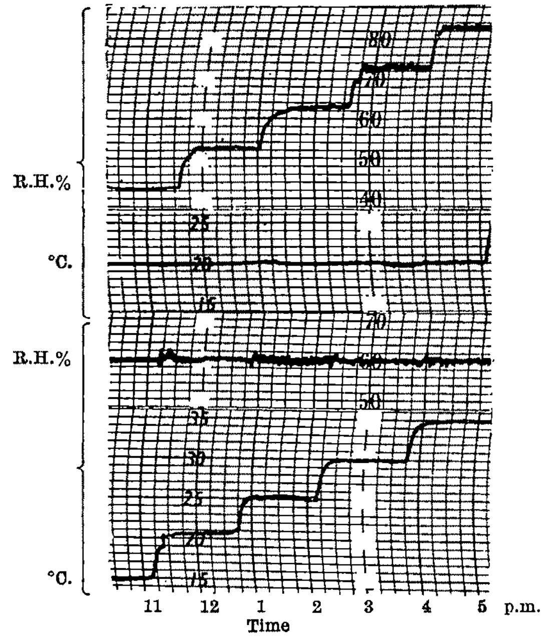

Fig. 2. Thermograph and hygrograph records taken in the working compartment. Upper part, various levels of humidity at constant temperature; lower part, various levels of temperature at constant humidity

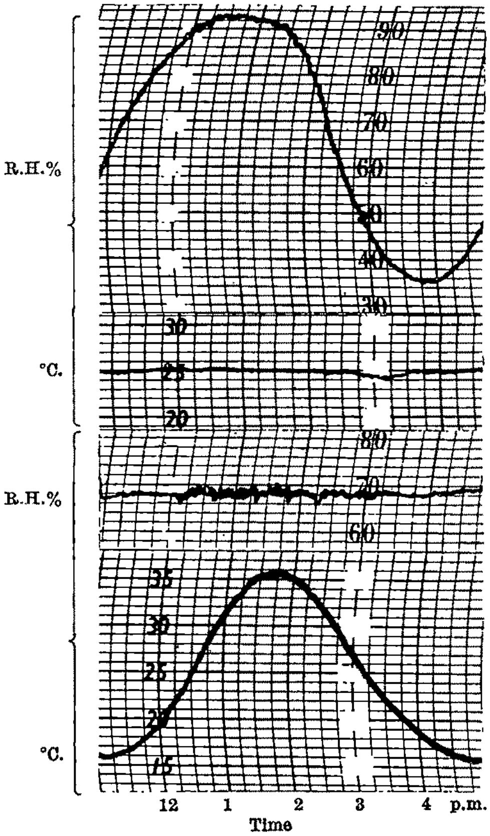

Fig. 3. Upper part, a programme of changing humidity at constant temperature; lower part, a programme of changing temperature at constant humidity

The success of this equipment can be attributed to three factors: (*a*) very sensitive control elements with low heat capacity; (*b*) equipment arranged to give clear-cut 'on : off' with as little carry-over as possible; this meant heaters of low heat capacity, refrigerator with a by-pass air current which could be stopped instantaneously, as could the atomizers; (*c*) excellent mixing in sequence such as is only achieved in a circulatory system.

The working compartment represents a bench space of 36 sq. ft.—equivalent to that in a small room. It is suggested that the air conditioning of an enclosed bench with circulation in the form of a closed circuit air stream gives more precise control than that of a whole room with less good or irregular mixing. A more detailed description of this equipment will be published in due course elsewhere.

We wish to thank the Nuffield Foundation for a grant of £1,100 and the University of Nottingham for a grant of £475. These together provided a sum covering the total capital cost of the equipment and a small part of the labour costs. The glasshouse with its services and the major part of the labour costs were not covered by the grants. Thanks are also due to Prof. C. G. C. Chesters for his generous provision of departmental facilities, to Mr. J. H. Broadbent for his skill and patience in constructing the tunnel, and to many colleagues for their advice.

SERUM ANTIBODY AND γ-GLOBULIN IN BABY RABBITS AFTER TRANSFER OF RIBONUCLEOPROTEIN FROM ADULT RABBITS

By Dr. MIROSLAVA HRUBEŠOVA*, Dr. BRIGITTE A. ASKONAS and Dr. J. H. HUMPHREY

National Institute for Medical Research, London, N.W.7

BABY rabbits in the first days of their life do not appear to give an antibody response to various substances, such as *Salmonella* antigens, *Brucella* antigens and bovine gamma-globulin, which are potent antigens in adult animals. The earliest age at which an antibody response can be elicited is usually about 20 days[1], though with large amounts of *Salmonella* antigen there may be some response in 10-day-old rabbits. This failure to form antibodies appears to be correlated with the fact that young animals do not form γ-globulin in appreciable quantities[2,3].

Recent work by Šterzl and Hrubešova[4] has shown that detectable antibodies to *Salmonella paratyphi B* appeared in the blood 3–5 days after intraperitoneal injection into 5-day-old rabbits of a ribonucleoprotein preparation from the spleens of normal adult rabbits, which had themselves received a dose (5×10^8 organisms) of heat-killed *Salmonella* two days previously, but the serum of which did not at that time contain detectable agglutinins. The injected ribonucleoprotein did not possess demonstrable antibodies as tested by the agglutination method.

It was of interest to know whether the antibodies in the baby rabbits receiving ribonucleoprotein were formed *de novo* in animals too young to react to antigens or arose from some transferred precursor. We attempted to determine this by injecting amino-acids labelled with carbon-14 into the babies and isolating the agglutinins. Newly formed antibody would be expected to be radioactive, whereas preformed antibody from the donor would remain unlabelled.

Isolation of Agglutinates following Injection of Ribonucleoprotein and Amino-acids labelled with Carbon-14 into Baby Rabbits

A suspension containing 5×10^8 heat-killed organisms of *Salmonella typhimurium* Glasgow (which has the same *O* antigen as *S. paratyphi B*) was injected, intravenously, into normal adult rabbits; donor rabbits were selected with serum agglutinin titres to *S. typhimurium* not exceeding 1 : 2. Two days later ribonucleoprotein was prepared from a saline extract of spleen by precipitation with ethanol[4] and injected, intraperitoneally, into half of a litter of 5-day-old baby rabbits, the litter mates being used as controls. In different experiments the babies received 400–900 μgm. of ribonucleoprotein containing less than 15–30 per cent of ribonucleic acid (based on estimates of total nitrogen and phosphorus). On the seventh and eighth postnatal day the injected and control babies each received, intraperitoneally, equal doses (35–50 μc. ≏ 1 mgm.) of amino-acids labelled with carbon-14 prepared by acid hydrolysis of biosynthetically labelled *Chlorella* protein (Radiochemical Centre, Amersham) and they were killed on the ninth postnatal day. These times were chosen in the light of the experiments of Šterzl and Hrubešova[4] showing that antibody titres reached a maximum 4–5 days after injection of ribonucleoprotein.

The sera from each group of baby rabbits were pooled and fat particles were removed by centrifuging for 60–90 min. at 18,000 *g*. The agglutinin titre was determined using 1 ml. of serum. The remaining serum (4–5 ml.) from both groups of rabbits was treated identically to determine the radioactivity of the specific agglutinins, and non-specific serum proteins absorbed on to the bacteria. Excess *S. typhimurium* (0·7–1 × 10^9 organisms/ml. serum) were added to the serum, which had been diluted with an equal volume of saline containing 0·2 per cent of neutral ethylene diamine tetraacetate and 30 mgm. mixed amino-acids (added to minimize adsorption of amino-acids labelled with carbon-14 and complement on the organisms). After 2 hr. at 37° C. and 2–3 days at + 4° C., the organisms were collected by centrifugation, washed twice with normal rabbit serum (containing no detectable agglutinins), once with saline and once with water. The organisms were suspended in 5 *N* ammonium hydroxide, dried on 2 cm.^{2} polyethylene disks and their radioactivity determined at infinite thinness with a thin window counter. To obtain the specific radioactivity of the agglutinins, the amount of protein absorbed on the bacteria was determined by the method of Lowry *et al.*[5] after extracting the organisms with 0·1 *N* sodium hydroxide. The extractable protein content of the organisms was determined by washing and extracting a saline suspension in the same way, and was deducted so as to obtain the amount of protein absorbed on the bacteria from the sera.

The results of such experiments are shown in Table 1. Although in two of the three experiments *O* agglutinins appeared in higher titres in serum of babies treated with ribonucleoprotein from injected donors than in serum of controls, it is evident that considerable non-specific adsorption of serum proteins on the bacteria occurred in all cases and there were no striking differences in the specific radioactivity of the absorbed proteins in the different groups of rabbits. By comparing agglutinin titres and precipitating antibodies of a serum from a rabbit hyperimmunized against purified soluble *O* antigen, we have estimated that an agglutinin titre of 1/16, under our experimental conditions, corresponds to less than 0·4 μgm. antibody per ml. Thus, the amounts of specific antibody to be sought in the babies' serum samples were not more than 2 μgm. To measure the radioactivity of such small quantities would only be possible if non-specific uptake of other proteins could have been completely eliminated. Therefore, no conclusions can be drawn as to whether or not the agglutinins were formed *de novo*

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* Present address: Biological Institute, Czechoslovak Academy of Sciences, Prague, Czechoslovakia.

Table 1

Exp. No.†	Material injected	Agglutinin titre of pooled sera	Weight of serum protein eluted from bacteria (μgm./ml. serum)	Sp. activity of serum protein eluted from bacteria (cts./min./100 μgm.)
694	RNP from injected donor	1/16 +	20	94
	—	1/4 ±	13	76
740	RNP from injected donor	1/2 +	65	27
	—	1/2 ±	81	30
800	RNP from injected donor	1/16 +	36	113
	—	1/4 ±	17	150
724	RNP from normal donor and 0·5 μgm. *O* antigen	1/2 −	152*	15·7
	0·5 μgm. *O* antigen	1/2 −	124*	28·3
	—	1/2	122*	23·2

* *S. typhimurium* organisms added to undiluted serum in the absence of versene.

† Litter mates were used for each experiment with 2–3 babies per group.

RNP = ribonucleoprotein.

in the baby rabbits which received ribonucleoprotein.

Test for Preformed Antibody in Ribonucleoprotein

The possibility that antibodies were passively transferred with the ribonucleoprotein preparation was considered by Šterzl and Hrubešova[4], but they could not detect agglutinins in the material which they used for transfer. We found that the sera of normal rabbits from all the stocks available to us—even though classed as negative by direct agglutination tests—contained detectable antibodies (1/8–1/16) against the *O* antigen of *Salmonella typhimurium*, when tested by the more sensitive hæmagglutination technique[6], using red cells sensitized with a purified *O* antigen kindly provided by Dr. D. A. L. Davies. This suggested that the rabbits might have been subject to weak stimulation with some related antigen (for example, from the intestine or from inhaled dust); this suggestion was strengthened by observing that injection of 0·02 μgm. of the *O* antigen into our normal rabbits gave rise to high titres of agglutinins within 4 days—characteristic of a secondary, rather than of a primary, response. If this is so, it might be expected that the spleen taken from donor rabbits two days after injection of *S. typhimurium* would already be making some antibody, and that the ribonucleoprotein fraction (which was prepared in in such a way as to contain γ-globulin) might contain sufficient antibody to give rise to agglutinins in the recipient babies.

We therefore re-investigated this question, and treated the ribonucleoprotein with ribonuclease, trypsin and carbonate buffer *p*H 9·5, in an attempt to release antibody complexed with nucleic acid or other proteins. We were, however, unable to detect preformed agglutinins in the ribonucleoprotein by the hæmagglutination technique. With the possibility in mind that living tissue might split off antibody, ribonucleoprotein was added to the perfusing fluid in the isolated perfused lung system described by Askonas and Humphrey[7], and the fluid was examined for the presence of antibody after various time intervals. None was detectable after up to 6 hr. of perfusion. Furthermore, we found that ribonucleoprotein had no inhibitory effect on the agglutination reaction, even when tested with minute quantities of antibody. There is, therefore, no evidence that agglutinins appearing in the babies after three days were due to passive transfer of preformed antibody. If such transfer is the explanation, the antibodies must be present in some masked form. There is also the possibility that antigen–antibody complexes are present, since Šterzl and Hrubešova[4] found indirect evidence for occasional transfer of traces of antigen.

Incorporation of Amino-acids labelled with Carbon-14 into Plasma Proteins in Baby Rabbits

These experiments provided an opportunity for observing the degree of incorporation of amino-acids labelled with carbon-14 into plasma proteins in 7–9-day-old rabbits. After absorption of the sera with *S. typhimurium* the specific radioactivity of the remaining proteins was measured as follows: albumin, α-globulin and β-globulin were isolated from 1 ml. of serum by electrophoresis on treated cellulose columns[8]. The fractions were dialysed under pressure, protein precipitated with trichloroacetic acid, and the radioactivities of the dried washed proteins determined at infinite thickness. There was insufficient γ-globulin in these sera to permit isolation by this method, and we therefore used the diethylaminoethyl cellulose ion-exchange column described by Peterson and Sober[9]. By using 0·015 *M* phosphate buffer, *p*H 6·0, γ-globulin could be isolated, contaminated only, in some sera, with hæmoglobin. The extent of such contamination was estimated colorimetrically and, when it was significant, hæmoglobin was prepared from pooled red cells of the rabbits in the same experimental group, and its specific activity measured, in order to permit correction of the γ-globulin radioactivity measurements.

The total protein content (by Kjeldahl nitrogen estimation) of 9-day-old rabbits' sera was about two-thirds that of adult serum. The percentage of the component serum proteins was similar in all groups of baby rabbits, as judged from the elution diagrams of the columns based on the ultra-violet absorption of the protein at 280 mμ. Sera from adult rabbits were treated similarly, for comparison, and average values are given in Table 2. The concentration of γ-globulin was about 1 mgm./ml. as confirmed by immunochemical estimations, using goat anti-rabbit serum rendered specific for rabbit γ-globulin by absorption with other rabbit serum fractions.

Table 2. PROTEIN COMPOSITION OF SERA OF 9-DAY-OLD AND ADULT RABBITS

	Per cent of total serum protein (based on measurement of protein absorption at 280 mμ)	
	9-day-old rabbit	adult rabbit
Albumin	66·5	59
α-Globulin fraction	19·5	5·5
β-Globulin fraction	10·5	18·5
γ-Globulin	3·5	17

All the serum proteins became labelled, and it is of some interest to compare the relative specific activities with those found in adult rabbits 48 hr. after injection of a similar mixture of amino-acids labelled with carbon-14. Our findings are shown in Table 3, in which it may be seen that, with the exception of γ-globulin, the relative incorporation of amino-acids labelled with carbon-14 into the various fractions was similar in both treated and control groups of babies, and not very different from the results in the adult rabbit.

Table 3. RELATIVE RADIOACTIVITIES OF SERUM PROTEINS 48 HR. AFTER ADMINISTRATION OF AMINO-ACIDS LABELLED WITH CARBON-14 (Values are means of several experiments and are expressed as percentages of the radioactivity of serum albumin)

Group	Albumin	α-Globulin	β-Globulin	γ-Globulin
Adult rabbits	100	170	155	70
Control 9-day-old rabbits (3 exps.)	100	135	123	14
Babies (9 days) injected at 5 days with ribonucleoprotein (3 exps.)	100	134	133	38

Since the extent to which a labelled amino-acid becomes incorporated into plasma proteins depends upon several factors (such as the rates of synthesis and degradation, pool size, and amino-acid composition of the protein), detailed interpretation of these results is not possible with the results available. Comparison of the two groups of babies is, however, valid. Incorporation of carbon-14 into γ-globulin (and hence the rate of synthesis) is strikingly low in both groups, especially when the very small size of the γ-globulin pool is considered. However, it was two to three times greater in the rabbits which received ribonucleoprotein than in the controls, whether or not there was a detectable rise in antibody titre. This indicates that γ-globulin synthesis, although still very small, was stimulated by the injections of ribonucleoprotein. By what mechanism this effect was produced we are unable to say. In all but one experiment, in which the spleen of one control baby was quite abnormally large, the spleens of animals in the ribonucleoprotein groups were 10–40 per cent heavier than those of control animals, after correcting for any differences in body-weight. The possibility that this was due to stimulation of plasma cell proliferation by the ribonucleoprotein was examined histologically, in sections of spleen stained with pyronin and methyl green. Plasma cells were, however, too few to be detected, in any of the babies' spleens—an observation which excludes such cells from being the main factor in splenic enlargement, though not necessarily in γ-globulin formation.

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REACTION OF SOME SILICATES WITH CHELATING AGENTS

By DR. D. A. SUTTON, M. D. MIDDLETON and R. A. F. BODY

Pneumoconiosis Research Unit, Council for Scientific and Industrial Research,
South African Institute for Medical Research, Johannesburg

MINERAL silicates have been directly implicated as fibrogenetic agents in certain of the pneumoconioses (for example, asbestosis) and conceivably play a part in others. For example, Witwatersrand gold miners suffering from 'classical' silicosis have inhaled silicates in addition to quartz. If silicates and quartz dissolve *in vivo*, the silicate ions released may produce precipitated silicates by reaction with body metals. It was therefore decided to explore the reaction of some mineral and precipitated silicates with chelating agents. It was found that removal of metal from silicates resulted in breakdown of the silicate lattice and the release of silicate ion. Chelating agents may also be useful in that they offer possibilities for accomplishing ion exchange on the surface of the causative agents of the pneumoconioses; this is the subject of a forthcoming publication[1].

The silicates used were (*a*) olivine, crocidolite, antigorite, chrysotile, talc and orthoclase from South African mines; (*b*) those of Ca^{2+}, Mg^{2+}, Al^{3+}, Fe^{2+} and Cu^{2+} precipitated from aqueous solutions; (*c*) tricalcium silicate made at 1,500° C. Most experiments were done with ethylenediamine tetraacetic acid as chelating agent; but penicillamine and glycine were also tried.

100-mgm. samples of each mineral (1–100μ diameter particles unless otherwise stated) were agitated with 26·5 ml. aqueous 0·75 *M* ethylenediamine tetraacetic acid (trisodium salt), that is, enough to chelate several times the metal present. The reagent was buffered to *p*H 7·4 by adding 0·315 gm. H_3BO_3 and 0·05 gm. $Na_2B_4O_7.10H_2O$. Control experiments using the buffer solution only gave less than 10 per cent of the values obtained with ethylenediamine tetraacetic acid with most of the minerals and have not been deducted from the results presented except as indicated. In process 1, the reactions were not disturbed except for the removal of small volumes of supernatant for analysis. In process 2, the mixtures

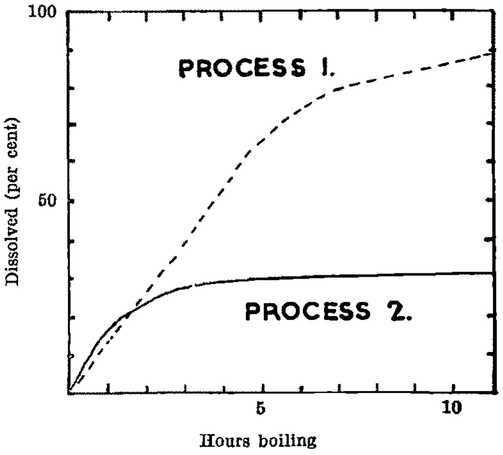

Fig. 1. Dissolution of antigorite and chrysotile in ethylenediamine tetraacetic acid

Table 1. REACTION OF MINERALS WITH ETHYLENEDIAMINE TETRAACETIC ACID

Mineral	Composition (by analysis)	Silicate (lattice type)	Reaction temp. (°C.)	Per cent dissolved using Process 1	
				1 hr.	2 hr.
Olivine	90 per cent Mg_2SiO_4, 10 per cent Fe_2SiO_4	Nesosilicate	93*	9·2†	11·5
Olivine	90 per cent Mg_2SiO_4, 10 per cent Fe_2SiO_4	Nesosilicate	37	3·3	4·8
Crocidolite	64 per cent $NaFe(SiO_3)_2$, 36 per cent $FeSiO_3$	Inosilicate	93	3·3‡	4·2‡
Antigorite	$Mg_3(OH)_4Si_2O_5$	Phyllosilicate	93	17·0†	20·6
Chrysotile	$Mg_3(OH)_4Si_2O_5$	Phyllosilicate (tubular)	93	20·6†	23·6
Chrysotile	$Mg_3(OH)_4Si_2O_5$	Phyllosilicate (tubular)	25	0·55	1·1
Chrysotile (1 cm. fibres)	$Mg_3(OH)_4Si_2O_5$	Phyllosilicate (tubular)	93	4·20†	
Talc	$Mg_3H_2(SiO_3)_4$	Phyllosilicate	93	0·7‡	1·0‡
Orthoclase	$KAlSi_3O_8$	Tectosilicate	93	0·0	0·0

* Boiling point of solution in Johannesburg.
† Reaction continues using process 2
‡ Reaction continues very slowly using process 2 ; the high control values (45–60 per cent) have been deducted.

were centrifuged hourly and the supernatants replaced by fresh reagent. The percentages dissolved were determined by silicate[2], iron[3] and magnesium[4] analyses as appropriate on the supernatants.

At 93° C., antigorite, chrysotile and olivine reacted fairly rapidly, orthoclase did not react, and crocidolite and talc reacted slowly. Antigorite and chrysotile continued to react until near completion using process 2 at 93° C. (Fig. 1), and the cessation of reaction noted in process 1 was due to the deposition of silicate on the particles. This was proved by taking antigorite which had ceased to react after seven hours, using process 1 at 93° C. and re-treating it with fresh reagent; the mineral then again began to dissolve, but the supernatant contained disproportionately more silicate than magnesium.

The 1-cm. chrysotile fibres reacted at about one-fifth of the rate of the powder, which was at least 200 times shorter. Antigorite and chrysotile particles of similar size reacted at almost identical rates (Fig. 1). In view of these facts and the published structures[5,6] of the two minerals, it appears that reaction with ethylenediamine tetraacetic acid probably occurs by abstraction of metal from the Mg—OH (outer convex) layer. In olivine, metal ions occur on outer surfaces, but in talc (which reacts very slowly) they do not. Crocidolite reacted slowly, although recent literature[7] groups it with amphiboles, that is, having metal ions on the outer surface. Orthoclase, in which aluminium replaces silicon in the lattice, does not react.

Neither glycine nor *d*-penicillamine, both of which are weak chelating agents, reacted with chrysotile at 93° C.

Precipitated silicates were prepared by adding sodium silicate solution with rapid stirring to metal salt solutions at 37° C. The *p*H's of the metal salt solutions had been adjusted so that the final *p*H after adding the alkaline (*p*H 11·5–12·0) silicate solution was as high as possible without causing precipitation of the metal hydroxide. The thoroughly washed precipitates were shaken for five minutes three times at 37° C. with 0·75 *M* ethylenediamine tetraacetic acid in 0·9 per cent saline (*p*H 7·4). The extents of reaction were determined by analysis of the supernatants, namely, for calcium (flame photometry on the oxalate), magnesium[4], aluminium[8], iron[3], and copper (as the ethylenediamine tetraacetic acid chelate colorimetrically at 725 mμ).

Table 2. REACTION OF PRECIPITATED SILICATES WITH ETHYLENEDIAMINE TETRAACETIC ACID

Metal	m.moles metal mixed with 1 m.mole silicate (as SiO_2)	Mixture volume (ml.)	m.moles metal per m.mole silicate (as SiO_2) in precipitate	Percentage reaction
Ca^{2+}	0·44	6·3	0·24*	
Ca^{2+}	1·02	2·7	0·46	100
Ca^{2+}	2·18	10·3	1·3*	
Ca^{2+}	15·00	163·0	2·1*	
Mg^{2+}	1·03	2·7	0·56	100
Al^{3+}	1·03	5·2	0·68	13
Fe^{3+}	0·98	7·7	0·26	100
Cu^{2+}	1·03	2·7	0·71	100

* Included to show that composition depends on ratio of metal/silicate used.

Only the precipitated aluminium silicate failed to dissolve completely under the conditions used. Aged copper silicate (five weeks) behaved in the same way as that freshly prepared.

Synthetic tricalcium silicate[9] (actually 70 per cent $3CaO.SiO_2.1\frac{1}{3}H_2O$ and 30 per cent $5CaO.2SiO_2.H_2O$ [10]) dissolved within five minutes at 25° C. in the ethylenediamine tetraacetic acid solution. This material thus reacted far more rapidly than olivine, a member of the same structural group.

It is apparent that ethylenediamine tetraacetic acid at body temperature reacts so slowly with the mineral silicate types studied that its therapeutic application in this respect, if any, will be restricted to a few special cases. Since magnesium is lower in the ethylenediamine tetraacetic acid – metal stability series than calcium, calcium ethylenediamine tetraacetic acid is, in any event, inapplicable to the *in vivo* removal of olivine, chrysotile or antigorite. Precipitated silicates of metals higher than calcium in the ethylenediamine tetraacetic acid series (if they exist *in vivo*) would probably be removable by calcium ethylenediamine tetraacetic acid.

We wish to record that we decided to carry out this work following the administration of calcium ethylenediamine tetraacetic acid to a miner which had been suggested by Dr. Harriet Hardy.

We thank Dr. I. Webster for discussion, Dr. H. F. W. Taylor for the tricalcium silicate and Mr. W. J. van Biljon for mineral silicates. Some of the preliminary experiments were carried out with Mr. L. W. Marasas.

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Possibility of Ion Runaway in Zeta

Above a certain critical velocity the rate of loss of momentum of an ion in Coulomb collisions with other particles decreases with relative velocity. This leads to the possibility that ions in a plasma can be continuously accelerated by an electric field. Such ions are called 'runaway' ions.

George[1] has suggested that some of the observations on Zeta[2] can be explained in terms of runaway ions. By modifying an expression[3] applicable to runaway electrons and by ignoring ion – electron collisions, George obtains a condition for ion runaway based solely on ion – ion collisions. This procedure is not permissible. The velocity of those ions on the Maxwell tail of the ion distribution is much less than the mean thermal velocity of the electrons ($\overline{w}_e$) and so the frictional force on these ions due to the electrons increases with the ion velocity, and becomes very much larger than the ion – ion friction force. The class of electrons which can gain energy continuously consists, on the contrary, of the fastest particles in the plasma (apart from the runaways), so that their rate of loss of momentum decreases with increasing electron velocity.

The condition for an ion to 'runaway', in a fully ionized plasma, can be derived from the investigations of Chandrasekhar[4] by replacing his gravitational interactions by their electrical analogues. A singly charged test ion moving with velocity w_i through a Maxwellian distribution of electrons will experience a frictional retarding force given by[4,5]:

$$f = \frac{8\pi e^4 n_e \log\Lambda}{m_i} l_e^2 \left(1 + \frac{m_i}{m_e}\right) G(x) \tag{1}$$

where

$$\left.\begin{aligned} x &= l_e w_i,\ l_e^2 = m_e/2kT_e, \text{ that is, } l_e^2 w_i^2 = \frac{3}{2}\frac{w_i^2}{\overline{w}_e^2} \\ G(x) &= \frac{\Phi(x) - x\Phi(x)}{2x^2};\ \Phi(x) \doteq \frac{2}{\sqrt{\pi}}\int_0^x \exp(-y^2)\mathrm{d}y \end{aligned}\right\} \tag{2}$$

The subscript i refers to ions and e to electrons; m is particle mass; n, particle density; e, electronic charge; k, Boltzmann's constant; and Λ, the ratio of the Debye shielding distance to impact parameter for 90° deflexion[5].

If the velocity of the ion is less than the mean thermal velocity of the electrons then the frictional force increases with the relative velocity; if, on the other hand, the ion velocity is greater than the mean electron velocity the friction force decreases with increasing velocity.

First let the velocity of the test ion be appreciably greater than the mean thermal velocity of the electrons, in particular if:

$$w_i/\overline{w}_e > 1{\cdot}6 \tag{3}$$

then from (2), to within about 5 per cent:

$$G(l_e w_i) \simeq \frac{1}{2 l_e^2 w_i^2} \tag{4}$$

and (1) becomes:

$$f = \frac{4\pi e^4 n_e \log\Lambda}{m_e}\ \frac{1}{w_i^2} \tag{5}$$

that is, the friction force is proportional to $1/w_i^2$.

Thus, for sufficiently high initial velocity, the applied electric force will exceed the friction force and the test ion will runaway. In Zeta, however, the velocity of the ion is only greater than the mean thermal velocity of the electrons if the ion energy is greater than 200 keV. (assuming $T_e = 5 \times 10^5$, see ref. 6). The observed[7] ion energies are less than 20 keV.

Now let the ion velocity be less than the mean velocity of the electrons, say:

$$w_i/\overline{w}_e < 0{\cdot}5 \tag{6}$$

then from (2)

$$G(l_e w_i) \simeq 0{\cdot}376\, l_e w_i \tag{7}$$

and (1) becomes:

$$f = \frac{8\pi e^4 n_e \log\Lambda\ m_e^{1/2}}{(2kTe)^{3/2}} \cdot 0{\cdot}376\, w_i \tag{8}$$

that is, the friction force increases with increasing velocity and runaway is not possible. In fact, the ions reach a terminal velocity which is given by equating the applied electric force to the friction force; it is:

$$w_T = \left(\frac{ET_e^{3/2}}{n_e}\right)\frac{k^{3/2}}{\pi e^3 \log\Lambda\ m_e^{1/2}} \times 0{\cdot}94 \tag{9}$$

Since w_T has been calculated using a stationary Maxwellian velocity distribution for the electrons, it is relative to the drift velocity of the electrons. The electric field acting on the ions also acts on the electrons, and hence the terminal velocity w_T is physically the same as the drift velocity of the electrons, relative to the ions, which governs the resistivity of the plasma. The present calculation does not take into account the fact that the electron and ion distributions in an electric field are not Maxwellian and so cannot give an accurate value for the electron–ion drift velocity. A more accurate value is implicit in the distribution function obtained by Cohen *et al.*[8].

The above considerations show that runaway ions cannot occur in the conditions which apply on the average in Zeta. It is still, of course, possible that ion 'runaway' occurs in restricted regions of the discharge where conditions are abnormal. Examples of such regions are: regions where the electron velocity is limited by other means than collisions with the deuterons; regions of low electron temperature into which particles may be injected, from other parts of the plasma, with sufficient energy to satisfy (3); regions largely occupied by runaway electron streams, where ion – electron collisions are unimportant.

There is as yet insufficient evidence to show whether or not any such regions exist.

I am indebted to E. R. Harrison, R. S. Pease and W. B. Thompson for many discussions on this subject.

A. GIBSON

U.K. Atomic Energy Research Establishment,
Harwell, Berks.
Dec. 9.

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A Non-Thermal Direct-Current Plasma-heating Mechanism

THE power required to heat a plasma to thermonuclear temperature may be greatly reduced if one can apply the ion relaxation principle suggested by Schlüter[1] and also (in a different form) by Motz (unpublished work). In the Schlüter scheme, an oscillation in a magnetic field-strength at a frequency much lower than the frequency of electron collision heats the ions quickly, without appreciably heating the electrons. Since, in a plasma at equilibrium, the electrons are responsible for nearly all the loss of heat, this is a great advantage. In this communication it is shown that, under the influence of an axial unidirectional electric field (as in Zeta and Sceptre), the orbits of electrons in a plasma are distorted in such a way that they feed power to travelling compression waves in the plasma. It is conceivable that, by this means, and with a suitable choice of parameters, a substantial fraction of the total power available to a ring discharge might be converted to ion energy.

Let us suppose that the magnetic field, B, is:

$$B_z = B_0 [1 + \alpha^2(z - v_a t)^2] \tag{1a}$$

$$B_r = -\alpha^2 B_0 (z - v_a t) r \tag{1b}$$

with B_0 and α constants, z, r and t position and time co-ordinates, and v_a the velocity of the potential well. (In a gas discharge, v_a will be approximately the Alfvén velocity, $cB_0(\varepsilon_0/\rho)^{1/2}$; see also ref. 2.) An electron moving in this magnetic field can be characterized by its magnetic moment μ, where:

$$\mu = m v_\perp{}^2/2B \tag{2}$$

with $v_\perp$ being the component of the velocity normal to B. The parameter μ is very nearly a constant of the motion[2]. We consider motions in the vicinity of the $z - v_a t$, r origin. The restoring force on the electron is:

$$f = -\mu \nabla_{z'} B = -2\mu\alpha^2 B_0 z' \tag{3a}$$

where $z' = z - v_a t$. The electron thus has simple harmonic motion about $z' = 0$, at an angular frequency ω, where:

$$\omega = (2\mu\alpha^2 B_0/m)^{1/2} = \alpha v_\perp (z' = 0) \tag{3b}$$

In this motion, the magnitude, v', of the velocity of the electron, measured in the primed frame, is also nearly constant. If a small electric field, $-E_z$, is applied, so that $|eE_z/\alpha m v'^2| \ll 1$, the motion is still nearly harmonic, but the oscillation will now be centred about $z' \simeq eE_z/2\mu B_0\alpha^2 = z_0$.

For a simple example, suppose the electron orbits in a plane normal to the z-axis at z_0. The force eE_z on the electron is balanced by the magnetic force $ev_\perp B_r$, and in a time-interval Δt the work done on the magnetic field is $\Delta W_z = f_z \Delta z = ev_\perp B_r \Delta z = eE_z v_a \Delta t$. In this case, all the work done upon the electron by the E_z field is passed on to the B field.

In the above example, the radial component of the force did no work. This is also true for the case of an electron which oscillates in z', when we average over a complete cycle. Choosing an appropriate z-axis, we have $mv_\perp = B_z e r$, and:

$$\frac{\mathrm{d}r}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{mv_\perp}{eB_z}\right) = \frac{m}{e}\left[\frac{1}{B_z}\frac{\mathrm{d}v_\perp}{\mathrm{d}t} - \frac{v_\perp}{B^2{}_z}\frac{\mathrm{d}B_z}{\mathrm{d}t}\right] \tag{4}$$

while, using (2), we have:

$$mv_\perp \frac{\mathrm{d}v_\perp}{\mathrm{d}t} = \frac{\mu \mathrm{d}B_z}{\mathrm{d}t} \tag{5}$$

setting μ constant. Combining (2), (4) and (5), we get $\Delta W_r = \int f_r v_r \mathrm{d}t = \int ev_\perp B_z \frac{\mathrm{d}r}{\mathrm{d}t}\,\mathrm{d}t = \mu\Delta B$, which vanishes, when taken over a complete cycle.

For the work done against B_r in the vibratory case, we use (1*b*), (2), and the centrifugal force equation, getting $f_z = ev_\perp B_r = 2\alpha^2\mu B_0 z'$. Setting $z' = z_0 + z_m \sin\omega t$, and $v_z = v_a + \omega z_m \cos\omega t$, we have:

$$W_z = \int f_z v_z \mathrm{d}t = 2\alpha^2 B_0 \mu \int (z_0 + z_m \sin\omega t) \times (v_a + \omega z_m \cos\omega t)\mathrm{d}t \tag{6}$$

which, after integrating, and substituting for z_0, gives:

$$\Delta W_z = 2\alpha^2 B_0 \mu z_0 v_a \Delta t = eE_z v_a \Delta t \tag{7}$$

for the work done during a complete cycle.

If E_z is reversed, this effect gives a decrease in the energy of the magnetic perturbation.

It is tempting to generalize this result into the following rough rule: in a plasma, an electron that moves undisturbed through a complete vibratory cycle in its B potential well will divert all the energy it has gained from E_z in the interval to the magnetic field.

The fraction of the electrons in a discharge which will feed energy in this way to the compression waves in B will depend upon the electron temperature and the amplitude oscillations of intensity B. Under suitable conditions, the oscillations will be built up, and, if their frequency is appropriate, they will heat the plasma ions by the Schlüter mechanism. It is possible that such oscillations contribute to the remarkably fast ion heating in current experiments[3].

This work was supported by the U.S. Air Force.

DARYL REAGAN

Engineering Laboratory,
19 Parks Road,
Oxford.
Oct. 9.

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Difference between Cosmic-Ray Equator and the Geomagnetic Dip Equator

After several recent measurements on the latitude effects of cosmic-ray intensities[1-3] it has been suggested that the cosmic-ray equator coincides well with the geomagnetic dip equator rather than the geomagnetic dipole equator. Even if this is so, however, there is still a considerable discrepancy between the cosmic-ray and dip equators. One explanation of this discrepancy may be an inaccuracy of the position of the dip equator itself, because the dip equator is a curve obtained by interpolations among the observation points.

During the voyage of the *Soya* on the second Japanese Antarctic Research Expedition, measurements of geomagnetic total intensities were carried out crossing the geomagnetic equator in the South China Sea. The daily range of total intensity (F) was found for each day around the geomagnetic equator and compared with that at the magnetic observatory at Muntinlupa, in the Philippines. Although the ratio of the range on the ship to that of Muntinlupa varied considerably from day to day, a smoothed curve shows a remarkable feature of F against geomagnetic dip angle, as shown in Fig. 1. It is clear that the region of maximum range in F is about 4° south of the geomagnetic dip equator.

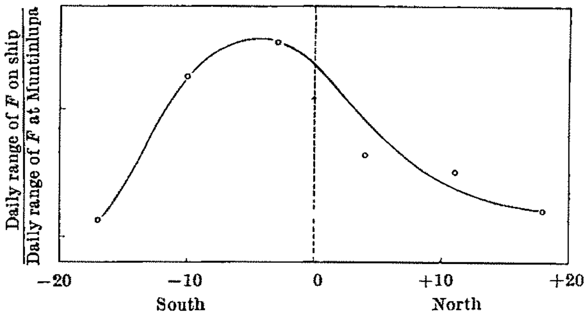

Fig. 1

On the other hand, cosmic-ray intensities measured on the same course during the first Japanese Antarctic Expedition show that the position of minimum cosmic-ray intensity was found at 6° north geographical latitude, which is situated at about 3° south of the geomagnetic dip equator[4]. Consequently, the cosmic-ray equator coincides with the geomagnetic dip equator deduced from the daily ranges of geomagnetic total intensities in the South China Sea, or along about 110° east geographical longitude.

These conclusions are valid on the assumption that the position of the geomagnetic dip equator is not necessarily accurately defined. Next, let us assume that the geomagnetic dip equator is accurate. In this case similar results are obtained around the geomagnetic dip equator in Africa[5], South America and India[6], except for a slight difference between the position of the maximum daily range in F and the geomagnetic dip equator. Since it has been suggested that an explanation can be found in the superposition of the effect of a narrow equatorial jet-current due to the Hall effect in the ionosphere[7], the area of maximum range in F is situated in the area of zero dip angle in the ionosphere. Therefore, it is suggested that the geomagnetic field is more effective in cosmic-ray intensities existing in the vicinity of 100 km. above sea-level than the geomagnetic surface anomalies, which decrease with height from the Earth's surface to the lower boundary of the ionosphere.

We would like to express appreciation to Prof. T. Nagata and Dr. Y. Miyazaki for their interest and encouragement during the expeditions.

Takashi Oguchi
Geophysical Institute,
University of Tokyo.
Masahiro Kodama
Institute of Physical and Chemical Research,
Tokyo.

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Infra-red Dispersion Wave-lengths for Solid Lithium Fluoride containing Varying Proportions of Lithium Isotopes

In a programme utilizing isotopic mass as a probe for the solid state, the infra-red dispersion wave-lengths of ^{6}Li^{19}F and ^{7}Li^{19}F were recently obtained[1]. Since then, improved apparatus and techniques have allowed a somewhat better estimate of these wave-lengths. Moreover, the study has been extended to lithium fluoride containing varying proportions of the lithium isotopes. Lithium fluoride was prepared by the action of hydrofluoric acid on metallic lithium and its oxide, nitride, etc., resulting from exposure to the atmosphere. The enrichment of the lithium-6 sample was specified as 99·3 ± 0·2 per cent, and that of the lithium-7 as 99·8 ± 0·1 per cent. Powdered samples of the appropriate composition were evaporated from a platinum boat on to $\frac{3}{4}$-mil polyethylene sheet. The thickness of the film of lithium fluoride as measured by the a.c. conductivity of a known volume of distilled water in which a fiduciary portion of the film plus sheet had been steeped, was about 0·2μ. Infra-red spectra were obtained by use of a Perkin–Elmer 'Model 21' double-beam spectrophotometer with a cæsium bromide prism.

Fig. 1 shows the results for the wave-length of the transmission minimum as a function of isotopic composition. Each circle represents a separate sample. The straight line is drawn through 32·6μ, the accepted value[2] for the fluoride of natural lithium (92·5 per cent lithium-7, 7·5 per cent lithium-6), with a slope such that the ordinates of the end-points are inversely proportional to the square root of the reduced masses of ^{6}Li^{19}F and ^{7}Li^{19}F, that is, 1·059. The best straight line fitting the results is a trifle steeper. Our estimate of the infra-red dispersion wave-lengths for 100 per cent enrichment is the following: ^{6}Li^{19}F, 30·8 ± 0·2μ; ^{7}Li^{19}F, 32·6 ± 0·2μ; ratio of wave-lengths, 1·058 ± 0·013. These values are in excellent agreement with those predicted recently by Stevenson and Nettley[3], namely, somewhat less than 30·9μ for ^{6}L^{19}F and somewhat exceeding 32·5μ for ^{7}Li^{19}F. Their values were deduced from measurements on the infra-red reflectivity of single crystals grown from fluorides made from enriched lithium.

The enriched isotopes were obtained and their analyses provided through Dr. P. S. Baker, Isotopes Division, Oak Ridge National Laboratory. We thank also A. G. Strelzoff and L. W. Hantel

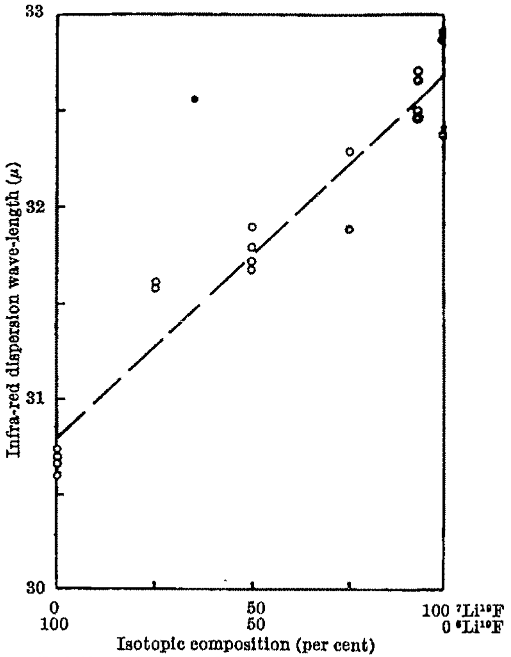

Fig. 1. Variation of infra-red dispersion wave-length of solid lithium fluoride with isotopic composition

for help in preparing the lithium fluoride and in evaporating the films. The U.S. Atomic Energy Commission and the Michigan State University All-University Research Fund kindly provided support for this work.

D. J. MONTGOMERY
R. H. MISHO

Department of Physics and Astronomy,
Michigan State University,
East Lansing, Michigan. Oct. 17.

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Optically Active Fluorite Films

THE possibility of evaporating in vacuum an optically active film of an otherwise isotropic material, by oblique deposition on to a flat glass substrate revolving about its normal as an axis, is confirmed. The helically deposited fluorite films ranged up to about 18μ thick, and turned the plane of polarization of a normally incident beam by as much as 2·25° at $\lambda = 0{\cdot}546\mu$.

Films deposited obliquely upon stationary substrates are usually anisotropic[1], a fact which helps to explain the optical activity of a helically deposited film. Thus, a film which is built up upon a revolving substrate can be envisaged as an anisotropic plate the azimuth angle of the fast axis of which continuously increases with depth. In this grosser sense, a helically evaporated film would resemble a Solc filter of the fan type[2], were the retardation plates of the Solc filter to approach zero thickness (and infinite number) while maintaining the total thickness of the filter constant. This model for the behaviour of the helically evaporated films would predict an optical rotation as a function of wave-length which could be compared with that of helically evaporated films.

From the point of view of the microstructure of the film, however, where the dielectric constant and hence the refractive index would depend upon alignment of the film structure, the activity of a helically deposited film could be due to the co-operative action of a helically symmetrical arrangement of crystallites, crystal growth or voids.

Experimental data were obtained for fluorite films which were deposited on circular microscope cover glasses. These were sprung against a relatively massive metal disk intended to minimize local differences of temperature, and to retard heating of the substrate by the vapour source. The metal disk, in turn, could be mounted on any one of three parallel shafts extended from the pinions of an electric-clock motor in the vacuum system, each turning at a different angular velocity. While spinning attached to the metal disk, the substrate was normally shielded from the vapour source by a corrugated brass shim-stock shutter less than an inch away. The shutter was operated by a rotary solenoid in the vacuum system energized through a switch on the fastest motor shaft and relays arranged so that the substrate would be exposed to the vapour source for an integer number of turns.

Evaporation was carried out at residual pressures no higher than 0·3μ mercury, the limit pressure due to outgassing of the motor and solenoid being about 0·1μ mercury. The vapour source was a molybdenum boat, in which about 0·5 gm. of synthetic crystal fluorite scraps were melted. The altitude angle of the vapour source with respect to the substrate was between 30° and 60°.

A Fizeau interferometer was used for measuring the optical thickness of each fluorite film. The optical activity of the film was measured using an *ETL–NPL* automatic polarimeter connected to a potentiometric chart recorder. In the presence of any birefringence in a sample film an oscillatory trace is obtained when the sample is rotated in azimuth. The mean angular rotation $\bar{R}$ of each film was taken as the interval, in angular units, between the chart record in the absence of a sample, and the mean value of at least four cycles of the oscillatory trace obtained from a helically deposited sample film. The birefringence which caused the oscillatory trace was expressed in terms of the maximum value of the ratio $(\bar{R} - R)/\bar{R}$, where $\tilde{R}$ is the optical rotation measured as a function of azimuth angle. The mean birefringence of all the samples was 19 per cent.

Measurements with the automatic recording polarimeter were always completed within a few minutes after deposition of the film. It was found that the optical activity of the helically deposited fluorite films decays a few per cent in the first day, but after several months rises.

It was found that the hand of the optical activity was always related to the hand of the substrate in the same way. Thus, a left-hand helically deposited film was always dextro-rotatory, and *vice versa*. Thus, as a ray travels through the film, the azimuth of the film and of the plane of polarization advance in opposite senses.

The relative advance of the plane of polarization of a ray crossing the film to the advance of film azimuth can be expressed by an advance ratio N_a. This advance ratio, $N_a = \bar{R}/360T$, for a number of helically evaporated films has been plotted against the film pitch P in Fig. 1.

Birefringence of the films was found to be smaller when an integral rather than a fractional number of turns were deposited. Considerable effort was spent trying to improve the constancy of vapour emission,

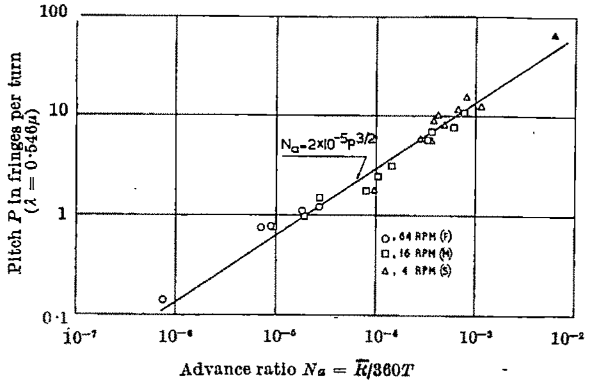

Fig. 1

as larger birefringence seemed to be associated with larger wedge angles in the completed film. Among other possible causes of the birefringence are the properties of the film at its boundaries or the presence of stresses.

For example, the properties of the film at the fluorite–air and the fluorite–glass interfaces cannot be expected to match those of the interior of the film.

The highest value of the specific optical activity reached in the experiments was 155°/mm. assuming a refractive index of 1·25 for the helically deposited fluorite film.

We are indebted to Dr. J. H. Mitchell, director of research, Ericsson Telephones, Limited, for permission to publish this communication.

NIELS O. YOUNG
JAKYM KOWAL

Instrument Division,
Ericsson Telephones, Limited,
Nottingham. Dec. 3.

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CHEMISTRY

Effect of Tartar Emetic on the Growth of Ammonium Dihydrogen Phosphate Crystals

THOUGH there are numerous examples of changes of habit in crystals produced by impurities in the mother liquor, it has scarcely been noticed that crystal habits are so changed by optically active impurities as to appear to be modified, due to the asymmetric structures of the impurities. Tartar emetic has been found to be one of such impurities which influence the growth of crystals of ammonium dihydrogen phosphate.

When optically inactive substances take part in the growing of the two faces which have the reflecting plane as the single element of symmetry, they are adsorbed on both faces in the same manner and so should influence the growth of the faces symmetrically. On the other hand, in the case of optically active impurities, even if they are adsorbed on one face, either they cannot be adsorbed on the other, or they may be adsorbed in a different manner, and consequently the effect may be different on the two faces.

A crystal of ammonium dihydrogen phosphate has bipyramidal and prismatic faces as shown in Fig. 1. It belongs to the tetragonal scalenohedral class, and the two adjacent pyramidal or prismatic faces are symmetric only with respect to the plane containing the Z axis and one of the two diagonal axes, P_1 and P_2. The two diagonal axes are distinguished by piezoelectric tests, and, after Mason[1], P_1 is taken as the axis along which a tension produces a positive charge at the positive end of the Z axis. But, so far as the habit is concerned, ammonium dihydrogen phosphate appears to be so highly symmetric that no difference can be observed in the behaviour among the faces of each form not only in pure solution but also in solutions containing various metal ions which are known to influence the crystal growth. This is due to the fact that the substances adsorbed on the growing faces are all optically inactive.

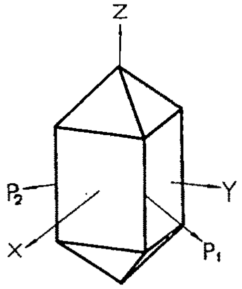
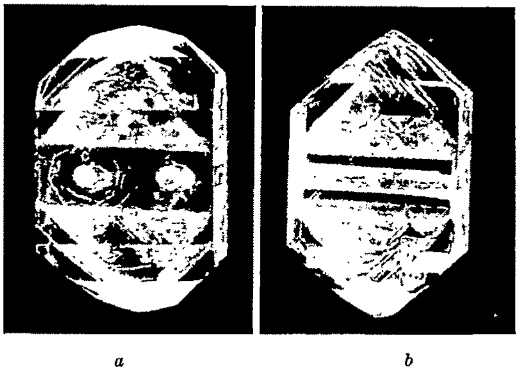


Fig. 1. Crystal form and crystal axes of ammonium dihydrogen phosphate

Crystals of ammonium dihydrogen phosphate were allowed to grow in solutions containing *d*-tartar emetic in different concentrations for one or two days at about 38·5° C. The temperature of each solution was kept 1 deg. C. lower than saturation point. In the lower concentration-range, the growth-rate of the pyramidal faces decreased gradually with increasing concentration, but there was no difference between the rate of growth of the (101) and (011) faces. When the concentration reached 3×10^{-3} M, peculiar changes were observed. Figs. 2*a* and *b* show photographic views of a crystal along the X and Y axes respectively. The summits of the bipyramid are rounded. The natural pyramidal faces develop only partly from the edges of the adjacent prismatic faces, and the area of the (011) faces is very much diminished. The growth-rate of the (011) faces decreases to 70 per cent of that measured in the solution without impurities; on the other hand, that of the (101) faces drops to 12 per cent. The former is equal to the value extrapolated from the results in the lower concentration-range.

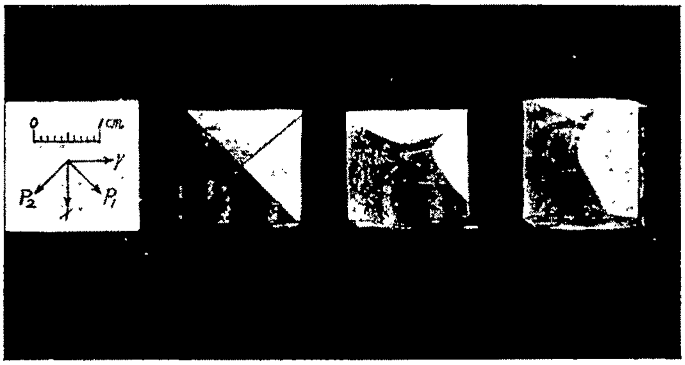


a *b*

Fig. 2. Effect of *d*-tartar emetic on an ammonium dihydrogen phosphate crystal; *a*, viewed along the X axis; *b*, along the Y axis. Two holes were drilled through the crystal for mounting on a crystal holder

Next, in place of *d*-tartar emetic, *l*-tartar emetic was added to the solution at the concentration of $3 \times 10^{-3} M$, and the crystals were grown in the same conditions as described above. The *l*-compound appears to have an effect symmetrical to that of the enantiomorph.

Fig. 3 shows the pyramidal faces of the crystals obtained from three different sources, which are viewed along the Z axis in the position shown at the left side of the figure. *a* shows the normal form obtained from the pure solution, *b* and *c* the effects of *d*- and *l*-tartar emetic respectively. Bright faces correspond to ($\bar{1}$01) and (011) of each crystal. In Fig. 3*c* the (101) faces become small in area, and the (011) faces develop laterally as a result of marked retardation in the vertical growth. Each of the faster faces, (011) in Fig. 3*b* and (101) in Fig. 3*c*, forms a triangle with a round corner at the opposite position to the edge of the adjacent prismatic face. The locus drawn by the corner during growth appears as the ridge from the apex of the pyramid to that of the face. The direction of the ridges made by *d*-tartar emetic inclines, as shown in Fig. 3*b*, anticlockwise from the Y axis to the P_2 axis, and that by *l*-tartar emetic clockwise from X to P_2 as shown in Fig. 3*c*. In this manner, the habits of ammonium dihydrogen phosphate modified by *d*- and *l*-tartar emetic are symmetrical with respect to the planes of symmetry of the crystal.



a *b* *c*

Fig. 3. Pyramidal faces of ammonium dihydrogen phosphate crystals obtained from three kinds of solutions; *a*, without impurities; *b*, containing *d*-tartar emetic; *c*, containing *l*-tartar emetic, viewed along the Z axis in the position shown at the left side

Tartar emetic in aqueous solutions dissociates into the potassium and antimonyl tartrate ions. The former showed no effect on the growth of an ammonium dihydrogen phosphate crystal. The latter forms a stable complex ion which is scarcely hydrolysed in neutral or weakly acid solutions. Therefore the effect of tartar emetic should be due to the complex ion. Actually no change in habit was observed in the solution containing hydrochloric acid besides tartar emetic. This shows that the complex ion is decomposed and made ineffective. Since the tartrate ion has in itself no effect on the crystal growth, the antimonyl tartrate ion must be adsorbed on the crystal face through the action of the antimony atom or of the group surrounding it.

Yutaka Kunisaki

Research Laboratory,
Nippon Electric Co., Ltd.,
Minato-ku, Tokyo. Oct. 31.

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High-Temperature Oxidation of Zinc Sulphide

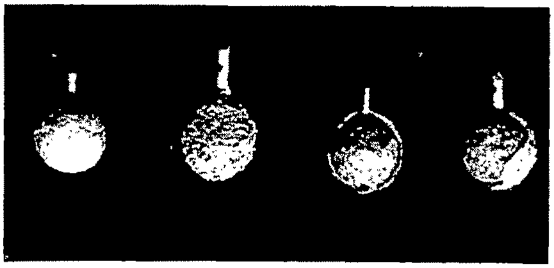
In earlier work[1] the rate of oxidation of the 110 faces of zinc sulphide was measured by use of a thermobalance. Below 830° C. the rate was found to be 'chemically controlled', being an exponential function of temperature and largely independent of the thickness of the product layer of zinc oxide. Above 830° C. there were indications of the onset of a 'diffusion control', depending on the diffusion of the oxygen up to the zinc sulphide interface through the layer of porous oxide.

In the present work we are extending these studies into the range 1,000–1,500° C. We find that above 1,150° C. the formation of zinc oxide no longer occurs on the surface of the zinc sulphide, but occurs instead at some distance from the surface in the gaseous phase.

A sphere of compressed zinc sulphide powder was suspended on a thread in a vertical tubular furnace. At $t = 0$ a nitrogen atmosphere surrounding the sphere was replaced by a stream of air. After a short period of reaction the sphere was removed and was found to be surrounded by a complete but very fragile concentric shell of oxide. Fig. 1 (*a*–*d*), referring to a temperature of 1,250° C. and a reaction-time of 1 min., show respectively a sphere before oxidation, a sphere after removal from the furnace and two spheres from which the shell has been partially removed. The gap between the oxide shell and the underlying zinc sulphide is clearly visible.

The vapour-pressure of the sulphide at high temperatures has been measured by Veselovski[2] and by Richards[3]. The latter has shown that the vaporization probably occurs with dissociation into zinc and sulphur. In our experiments it appears that these substances diffuse outwards from the surface of the sphere and meet oxygen diffusing inwards, thus giving rise to a deposit of zinc oxide at an approximately spherical and concentric reaction zone. As might be expected from the increasing volatility of the sulphide, the distance between the shell and the core increases with rising temperature and may be greater than 1 mm. over 1,300° C. (but depends also on the rate of air flow). The shell diameter appears always to be greater than the original core diameter, and the shell may perhaps have grown downwards from the support. The mechanism of the process thus appears to be similar to that of the diffusion flame surrounding a burning oil droplet.

Determinations of the rate of the oxidation process are being made by measurement of the rate of



(*a*) (*b*) (*c*) (*d*)

Fig. 1

evolution of sulphur dioxide. Our theory indicates that the reaction-rate per unit area may be expected initially (that is, before any significant thickness of shell has been formed) to vary inversely as the particle diameter and directly as the half-power of the Reynolds number (which determines the thickness of the boundary layer) together with a function of the temperature.

Gordon S. G. Beveridge
Kenneth G. Denbigh
Department of Chemical Technology,
University of Edinburgh and
Heriot-Watt College. Nov. 21.

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Separation of *m*-Xylene and *p*-Xylene by Gas Chromatography

Considerable interest has recently been centred on the difficult separation of *m*-xylene and *p*-xylene by gas chromatography both from the point of view of the analysis of mixtures containing these isomers and the assessment of the performance of high efficiency columns. Martin and James[1] predicted some years ago that it should be possible to achieve a separation using benzyldiphenyl as a stationary phase with a high-efficiency column and this was recently demonstrated by Zlatkis[2]. Similar partial separations have been described[3–5] with other stationary phases in long packed columns and by using long capillary columns[6]. Langer[7] has described the use of tetrahalophthalic esters as stationary phases which cause the meta isomer to be eluted before the para—the reverse of the usual order. (In an earlier paper[8], the relative retention volumes of *p*-xylene and *m*-xylene were incorrectly quoted in the reverse order for both *n*-hexatriacontane and benzyldiphenyl.)

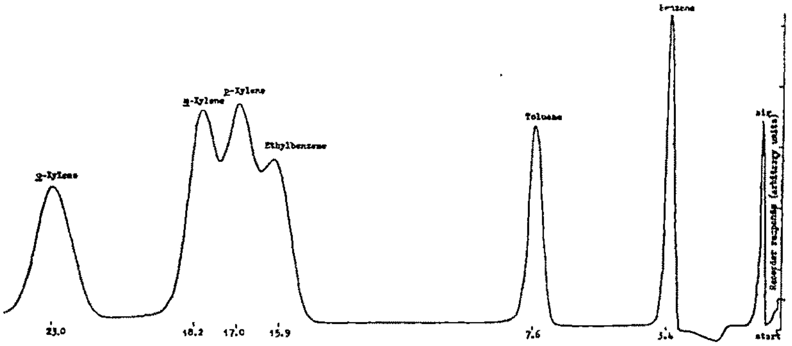
We have found that the aromatic nitrogen compound 7,8-benzoquinoline produces a better separation of the xylene isomers than any other stationary phase previously reported.

Table 1 shows retention-volume results at 78·5° C. for three established stationary phases and 7,8-benzoquinoline. Separation factors for *m*-xylene/*p*-xylene and *p*-xylene/ethylbenzene are also given together with the number of theoretical plates computed from Glueckauf's chart[9] required to bring about a separation of equimolar amounts of the isomers with a fractional impurity of 0·1 per cent in each band.

Table 1. Retention Volume Data at 78·5° C.

Index	Squalane	Benzyl-diphenyl	Tritolyl-phosphate	7,8-Benzo-quinoline
Relative retention vol. (benzene = 1)				
Toluene	2·513	2·342	2·299	2·473
Ethylbenzene	5·334	4·925	4·654	5·282
p-Xylene	5·975	5·242	4·934	5·639
m-Xylene	6·128	5·483	5·062	6·091
o-Xylene	7·307	6·858	6·494	7·827
Specific retention volume for benzene (ml./gm.)	95	91	86	78
Separation factor *p*-Xylene/ethylbenzene	1·120	1·064	1·060	1·068
Separation factor *m*-Xylene/*p*-xylene	1·025	1·046	1·026	1·080
Number of theoretical plates to effect 99·9 per cent purity (after Glueckauf) of *m*/*p*-xylene	60,000	20,000	55,000	7,000

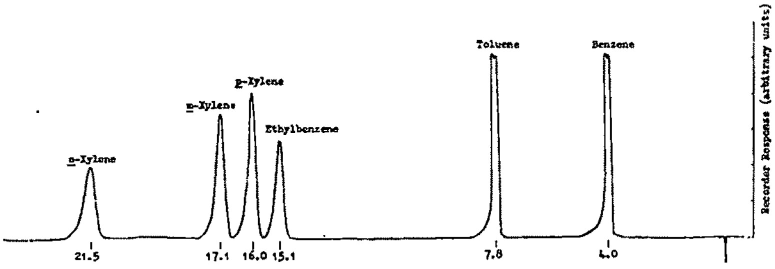
For comparison purposes, values from the literature of the separation factors for *m*-xylene/*p*-xylene are given in Table 2 together with the relative volatility at the operating temperature employed.



Time (min.)

Fig. 1. Separation of aromatic hydrocarbons on packed column:

Column	120 cm. × 0·4 cm. internal diameter
Column temperature	78·5° C.
Column packing	20 per cent weight 7,8-benzoquinoline on 72–100 mesh 'Celite' 545
Weight of packing	5·0231 gm.
Carrier gas	Nitrogen
Inlet pressure	111 cm. mercury
Outlet pressure	Atmospheric
Rate of flow	42 ml./min.
Size of sample	1 μl.
Efficiency	1,600 theoretical plates (*o*-xylene)
Detector	Martin gas density balance



Time (min.)

Fig. 2. Separation of aromatic hydrocarbons on capillary column:

Column	12 m. × 0·25 mm. internal diameter copper capillary coated with 12 mgm. 7,8-benzoquinoline
Temperature	78·5° C.
Carrier gas	Nitrogen
Inlet pressure	3 lb./in.^{2}
Rate of flow	0·7 ml./min.
Size of sample	Approximately 1 μgm.
Efficiency	14,600 theoretical plates (*o*-xylene)
Detector	Flame ionization

Table 2. SEPARATION FACTORS FOR m-XYLENE/p-XYLENE

Stationary phase	Temperature (° C.)	Separation factor	Relative volatility
n-Octadecane (ref. 1)	65	1·012	1·050
Paraffin wax (ref.1)	78·6	1·008	1·033
Lubrol Mo (ref. 1)	78·6	1·025	1·033
Benzyldiphenyl (ref. 2)	100	*ca.* 1·032	1·033
PEG(300)Dibenzoate (ref. 3)	65	1·038	1·050
PE Glycol (ref. 4)	*ca.* 50	1·035	1·065
Dodecylphthalate (ref. 6)	40	1·021	1·053
Di-n-propyl-tetrachlorophthalate (ref. 7)	110	0·962	1·033

7,8-Benzoquinoline offers a much easier separation of the xylenes while maintaining the ability to separate ethylbenzene from them. Fig. 1 shows the resolution achieved on a 4-ft. column having an efficiency of 1,600 theoretical plates. The isomers are completely resolved on a capillary column 12 m. long (Fig. 2).

The mechanism of this separation is obscure, but the configuration of the stationary phase molecule appears to be more significant than the presence of the nitrogen atom. Phenanthrene, the parent hydrocarbon necessarily used at a higher temperature above its melting point, shows similar results to 7,8-benzoquinoline at the same temperature (Table 3).

Table 3. COMPARISON OF 7,8-BENZOQUINOLINE, PHENANTHRENE AND BENZYLDIPHENYL AT 110·8° C.

Index	7,8-Benzoquoline	Phenanthrene	Benzyldiphenyl
Relative retention volumes (benzene = 1)			
Toluene	2·23	2·39	2·12
Ethylbenzene	4·28	4·61	3·96
p-Xylene	4·65	5·07	4·20
m-Xylene	4·90	5·35	4·37
o-Xylene	6·04	6·57	5·36
Specific retention for benzene (ml./gm.)	31	36	41
Separation factor m-Xylene/p-xylene	1·053	1·053	1·040
Separation factor p-Xylene/ethylbenzene	1·088	1·101	1·061

We wish to thank the chairman and directors of the British Petroleum Company for permission to publish this communication.

D. H. DESTY
A. GOLDUP
W. T. SWANTON

Research Station,
British Petroleum Co., Ltd.,
Chertsey Road,
Sunbury-on-Thames. Oct. 22.

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Rapid Specific Method for Determination of Aldosaccharides in Body Fluids

IN the clinical field it is of importance to have a rapid and exact method for glucose determinations. In order to avoid the non-specific reduction methods, a coupling reaction was worked out utilizing the conjugation of aldoses and ketoses with meta-aminophenol in acetic acid. After some preliminary experiments[1], a routine method was described[2]. The method has been used for some time in this laboratory and has proved satisfactory; but, because of the necessarily long boiling time of 30 min., and the fact that the whole range of urine sugar concentration cannot be read without dilution of the urine, it was considered an advantage to have a reagent giving a more rapid reaction and a wider range. Many aromatic amines have been tested; of these, one of the most suitable was *ortho*-toluidine, for which the optimal boiling time is 8 min. (Fig. 1). It gives a blue-green colour with maximum absorption at 6250 A. and is fairly specific for aldosugars (Fig. 2). Blood treated with glucose oxidase gave readings corresponding to 0–4 mgm. glucose per 100 ml. blood. With this reagent glucose quantities of 10–400 μgm. can be read directly in a Beckman *B* photometer.

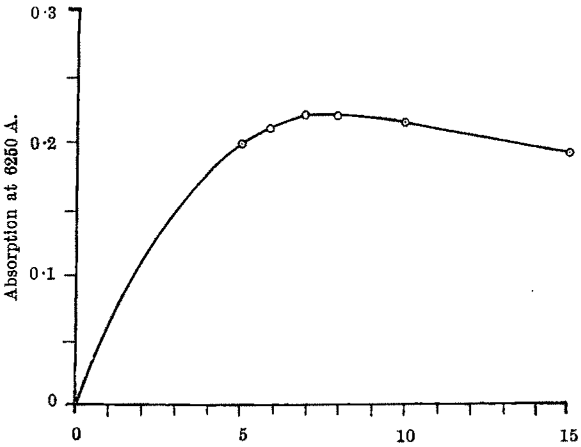

Fig. 1. Absorption of glucose colour after different times of boiling

Procedure for blood. 0·1 ml. whole blood is rinsed into 1 ml. of 3 per cent trichloracetic acid. After centrifugation, 0·2 ml. of the clear supernatant is mixed in a test-tube with 3 ml. of a 6 per cent solution of *ortho*-toluidine in glacial acetic acid. The tubes are placed in a boiling water-bath for 8 min., cooled, and read against a reagent blank at 6250 A. Standard glucose solutions are boiled together with every series. The procedure is the same as for blood. Blood sugar

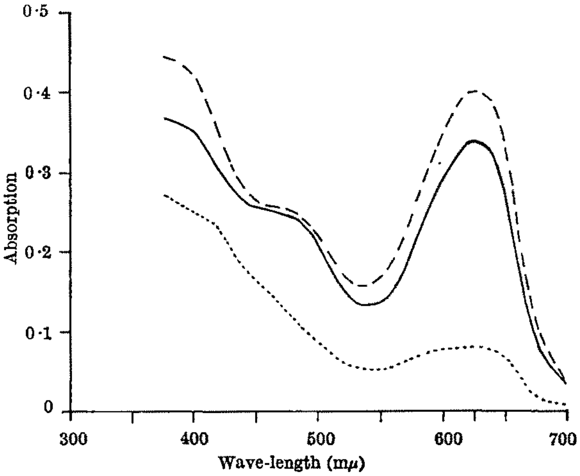

Fig. 2. Absorption spectra of the colour developed by different hexoses read in a Beckman *DK* photometer. ——, Glucose; – – – –, galactose; . . . . , lævulose

up to 800 mgm. per cent can be determined in this way. In a Beckman *B* photometer values down to 20 mgm. per cent can be read and still lower concentrations by changing the dilution of blood with trichloracetic acid. Serum or plasma can also be used. In this case protein precipitation is not necessary.

Procedure for urine. 0·004 ml. urine (measured with a micro-pipette[3]) plus 3 ml. of a 2 per cent solution of *ortho*-toluidine in acetic acid are boiled for 8 min., cooled and read against a reagent blank at 6250 A. and compared with standard glucose solutions. Benzoic acid does not interfere with the reaction and may safely be used as a preservative.

The reaction is very sensitive to water. The concentration of water should not exceed 10 per cent.

Technical grade *ortho*-toluidine is a brown solution which should be purified by distillation at ordinary pressure. The distillate is slightly yellow. The first 80 per cent of distillate is pure enough for direct use and seems to be stable for months, if kept in the dark. We use the Riedel de Haen product; but the practical grade *ortho*-toluidine (Eastman) is also suitable. The pure *ortho*-toluidine ('from nitrate') (Eastman) could be used directly without distillation.

The acetic acid should be of pure analytical quality. Both Riedel de Haen and 'Analar' products were used successfully. The reagent should be made fresh every day. If an automatic pipette is used for the reagent it should be all glass, as we have found the reagent to give false coloration with traces of metals.

Other aromatic amines tested could be used in a similar way. 2 : 6-Dimethyl aniline gave a similar absorption curve and was nearly as sensitive as *ortho*-toluidine to glucose but less sensitive to galactose; 2 : 5-dimethyl aniline gave lower values but was more sensitive to galactose than to glucose. Specific galactose determinations could possibly be made in this way.

The investigation was supported by grants from Föreningen för sockersjuka i Stockholm, Konung Gustav V : s årsfond and Svenska Livförsäkringsbolagens forskningsfond.

ERIC HULTMAN

Clinical Central Laboratory,
St. Erik's Hospital,
Stockholm. Nov. 12.

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Chemical Synthesis of Hexose and Hexosamine Sulphates

RECENT work[1] in these laboratories has been concerned with the enzymic degradation of naturally occurring aminopolysaccharide sulphates. Further extension of these studies necessitated the synthesis of a series of hexose and hexosamine sulphate esters. Methods for the sulphation of carbohydrates have been re-examined and procedures developed for the synthesis of authentic samples of glucose-6-sulphate and N-acetylglucosamine-6-sulphate.

In the following experiments carbohydrate sulphate esters were isolated as their barium salts, but for the purpose of paper chromatography and afterwards, preparative column chromatography on cellulose, these were converted to the free acids by passage through 'Dowex 50' (H^+ form) columns and then concentrated by distillation under reduced pressure and lyophilization.

Paper chromatography was carried out on Whatman 3*MM* filter paper using downward irrigation with butan-1-ol/acetic acid/water, 50 : 12 : 25, as solvent. Spots were made visible by spraying with alkaline silver nitrate or aniline hydrogen phthalate[3], and with Elson–Morgan reagents[4] for hexosamines. Ester sulphates were detected by a modification of the method due to Burma[5]. The technique used in chromatography on cellulose columns was essentially that of Putman[6], the developing solvent again being butan-1-ol/acetic acid/water, 50 : 12 : 25.

Direct sulphation of glucose with chlorosulphonic acid[7,8] yielded a heterogeneous product. Paper chromatography indicated the presence of three components, one identical with glucose, while the others contained ester sulphate. Column chromatography of the mixture yielded three peaks of reducing substance, the first of which was shown to be pure glucose. Analysis of the substances constituting the remaining peaks indicated that they corresponded to pure glucose monosulphate and disulphate respectively.

Definitive synthesis of glucose-6-sulphate was attempted using a method originally evolved for the preparation of glucose-6-phosphate[9]. Glucose was converted to 1,2,3,4-tetra-O-acetyl-β-D-glucose via 6-O-triphenylmethyl-1,2,3,4-tetra-O-acetyl-β-D-glucose using Reynolds and Evans's method[10]. The 1,2,3,4-tetra-O-acetyl-β-D-glucose was sulphated with chlorosulphonic acid and the product examined by paper chromatography. Two components were obtained, one identical with tetra-acetylglucose, and the other containing ester sulphate. Isolation of the components by column chromatography indicated the first member of the mixture to be pure tetraacetylglucose, while the second gave analysis figures which were consistent with it being 1,2,3,4-tetra-O-acetyl-β-D-glucose-6-O-sulphate. The latter was deacetylated by heating under reflux with 1 per cent acetic acid for 2 hr. Paper chromatography of the product indicated the presence of two components, one identical with glucose and the other containing ester sulphate. The latter was isolated by column chromatography and converted to the barium salt. On analysis it was shown to be pure barium glucose monosulphate. From the method of preparation this would appear to be authentic glucose-6-sulphate. The properties of barium glucose monosulphate, prepared by direct sulphation of glucose were identical with barium glucose-6-sulphate prepared by definitive synthesis.

The successful preparation of authentic glucose-6-sulphate by the above route suggested that a similar technique might be employed in the preparation of authentic N-acetylglucosamine-6-sulphate.

N-acetylglucosamine was prepared by Roseman and Ludoweig's method[11] and converted to 1,3,4-tri-O-acetyl-N-acetyl-β-D-glucosamine via 6-O-triphenylmethyl-1,3,4-tri-O-acetyl-N-acetyl-β-D-glucosamine by the method of Anderson and Percival[12]. The tri-O-acetyl-N-acetyl compound was sulphated as before and the products of reaction examined by paper chromatography. Two components were obtained, one identical with the starting material and the other containing ester sulphate. The latter was isolated by column chromatography and shown, by analysis, to be 1,3,4-tri-O-acetyl-N-acetyl-β-D-glucosamine-6-O-sulphate. After removal of acetyl groups by hydrolysis with acetic acid, paper chromatography indicated the presence of two components, one identical with N-acetylglucosamine and the other containing ester sulphate. The latter was isolated as the barium salt after column chromatography and gave analysis figures consistent with a structure of barium N-acetylglucosamine-6-sulphate. Barium N-acetylglucosamine-monosulphate, prepared by the direct sulphation of N-acetylglucosamine, was identical with barium N-acetylglucosamine-6-sulphate prepared by definite synthesis.

Further evidence as to the location of the sulphate group in position 6 of the hexosamine molecule was obtained by examining the behaviour of the compounds in the Elson–Morgan reaction[13]. Both authentic N-acetylglucosamine-6-sulphate and N-acetylglucosamine monosulphate gave 100 per cent colour production in this test using N-acetylglucosamine as standard. It has been shown that N-acetylhexosamines substituted in position 6 behave normally in the Elson–Morgan reaction whereas substitution in position 3 results in enhanced colour production. On the other hand, substitution in position 4 causes suppression of colour formation[14]. N-acetyl galactosamine monosulphate, prepared by direct sulphation of N-acetyl galactosamine[11], also gives 100 per cent colour formation in the Elson–Morgan test[13], providing preliminary evidence of the location of the sulphate group in position 6 of the molecule.

A more complete account of this work, together with the results of enzyme studies, will be given elsewhere.

I am indebted to the Empire Rheumatism Council for a research fellowship, and to Prof. J. Pryde and Dr. K. S. Dodgson for advice and encouragement during the course of the above work.

A. G. Lloyd

Department of Biochemistry,
University College,
Newport Road,
Cardiff. Oct. 22.

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Optical Rotation and Configuration of Poly-L-tyrosine

In a recent communication from this laboratory[1] it was reported that the constant b_0 in Moffitt's equation[2] for the optical rotation of a helical polypeptide is positive for solutions of poly-L-tryosine in dimethyl formamide and in pyridine, and for the sodium salt of this polymer in solution and in films. It was implied that in spite of the unusual sign of b_0 the polymer was in the α-helical form, and that the positive value is a consequence of the strong chromophoric group near the β carbon atom. We have since made further measurements of the optical rotation of a solution of this polymer in *N* sodium hydroxide and of films cast from a solution in dimethyl formamide at 60° C., together with observations of the infra-red spectrum and X-ray diffraction pattern of the films. These studies have led us to the conclusion that it is more probable that in dilute solutions in pyridine, in dimethyl formamide, and in aqueous alkali, poly-L-tyrosine is in the random coil configuration, as is its sodium salt in films.

The optical rotatory dispersion results are difficult to interpret unambiguously, because of the unknown effect of the chromophoric groups in the side-chain. There is no reason for supposing that the λ_0 of the Moffitt equation will be the same as in other polypeptides, that b_0 will be zero for a random coil arrangement, or indeed that the Moffitt equation will hold at all. However, if one nevertheless takes the usual value of 2120 A. for λ_0 and makes a Moffitt plot, one obtains values of b_0 of about $+300°$ for a solution in pyridine, about $+400°$ for solutions in dimethyl formamide and in *N* sodium hydroxide, about $+550°$ for films of the sodium salt, and about $-4000°$ for films of poly-L-tyrosine cast from dimethyl formamide. It is tempting to suppose that the configuration is different in the last case from that in the others, although the criterion is somewhat arbitrary. The distinction between the films cast from dimethyl formamide and the other systems gradually becomes less clear-cut as λ_0 is increased; however, so far as can be seen from measurements over a rather limited range of wave-length, the Moffitt plot gives the straightest line for a λ_0 of rather less than 2120 A.

Since at *p*H 14 the polymer is completely ionized, it would seem unlikely that the solution in aqueous alkali contains a large proportion of the α-helical configuration. On the other hand, infra-red spectroscopy and X-ray diffraction provide some evidence that the films cast from dimethyl formamide contain polypeptide in the α-helix form. Such films, when rolled, have been found to show marked infra-red dichroism of the kind associated with the α-helix. However, this behaviour is not reproducible, some similarly treated films failing to show any dichroism. The X-ray diffraction pattern of α-helices of poly-L-tyrosine packed hexagonally would be expected to have a strong ring corresponding to an interplanar spacing of 11·1 A., as may be calculated from the density of the films (1·254 gm./c.c.). The X-ray diffraction pattern of these films does indeed have a ring at 11·1 A.; but it is not particularly strong. Heating the films *in vacuo* at 130–140° C. for 2 hr. apparently crystallizes the polymer, and the subsequent X-ray pattern does show a strong 11·1 A. reflexion.

The results of these experiments are far from conclusive; but we feel that they strongly suggest that poly-L-tyrosine in each of the three solvents we have used, and its sodium salt in films, are in the random coil configuration, whereas in films cast from dimethyl formamide the polypeptide exists as α-helices.

We are indebted to Dr. T. Macdonald for taking the X-ray diffraction photographs in Courtaulds' X-ray Laboratory at Coventry.

A. R. Downie
A. Elliott
W. E. Hanby

Research Laboratory,
Courtaulds Ltd.,
Lower Cookham Road,
Maidenhead. Nov. 11.

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BIOCHEMISTRY and PHYSIOLOGY

Peroxidases from Wheat Germ

A PREVIOUS communication[1] described the preparation of two crystalline hæmoproteins (556) and (566), which possess strong peroxidatic activity. It was found in later investigations[2] that both hæmoproteins form complexes with hydrogen peroxide and are not reduced with diphosphopyridine nucleotide or succinate in the presence of an active homogenate or particles from wheat germ. This indicates that both hæmoproteins (556) and (566) are peroxidases and thus can be called peroxidase (556) and (566), respectively.

In the previous work, peroxidase (566) was obtained in very low yield. When the first ammonium sulphate precipitate cake from wheat germ extract was kept for several months, only peroxidase (556) and no peroxidase (566) was obtained. However, in the direct spectroscopic examination of wheat germ after reduction with sodium dithionite the predominant band is at 560–570 mμ, and that at 556 mμ is very weak.

We have therefore adopted a new method for the preparation of peroxidase (566), as follows. Wheat germ, without pretreatment by organic solvents, was suspended in five volumes of 0·1 *M* phosphate buffer of *p*H 7·0 and squeezed by pressing through a cloth. The fraction of the filtrate precipitated between 20 and 60 per cent saturation with ammonium sulphate was dialysed. It was then adsorbed on 'Amberlite' *CG*–50 equilibrated at *p*H 6·5 with 0·02 *N* ammonium phosphate buffer. After elution with 0·25 *N* buffer of *p*H 7·0, the eluate—in which peroxidase (566) was present in relatively larger amount but which contained no peroxidase (556)—was again adsorbed on 'Amberlite' *XE*–64 and eluted successively with 0·15 *N* and 0·25 *N* buffer of *p*H 7·0. Both fractions were separately chromatographed on 'Amberlite' *XE*–64 resin columns using 0·075 *N* and 0·10 *N* buffer of *p*H 7·0, respectively. Crystalline peroxidase (566), which has an octahedronal form, was obtained from both main effluents in the same way as in the earlier methods[1] (Fig. 1).

Peroxidase (566) thus obtained forms a stable complex with hydrogen peroxide which cannot be identified with any of the established complexes. This complex has absorption peaks at 415 mμ, 540 mμ and 570 mμ (Fig. 2. The Soret peak was determined by means of a Beckman spectrophotometer). Peroxidase (556), however, forms a very labile complex similar to complex II. Peroxidase (556) and (566) may be identified with peroxidase II and I, respectively, prepared from horse radish by Theorell[3]. According to Keilin and Hartree[4] peroxidase I is a modified form of peroxidase II.

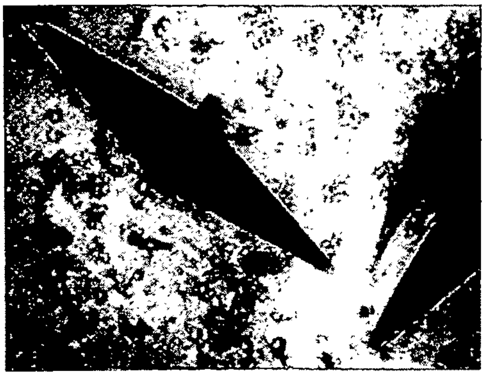

Fig. 1. Crystalline peroxidase (566). (Octahedron, × 200)

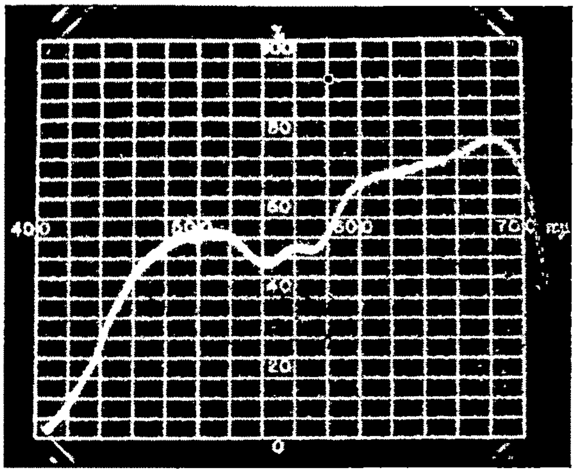

Fig. 2. Absorption spectrum of peroxidase (566)–hydrogen peroxide complex obtained with a rapid-scanning spectrophotometer. Reaction mixture contained about 0·5 per cent peroxidase (566), 0·005 *M* hydrogen peroxide and 0·06 *M* phosphate buffer of *p*H 6·0. The figure shows the spectrum of the complex in the visible region 5 min. after addition of hydrogen peroxide

Recently, Lundegårdh[5] obtained a peroxidase similar to peroxidase (556) from wheat roots treated with cold acetone. However, from the properties and behaviour during the preparation of the peroxidases, it seems that peroxidase (566) is the native protein, whereas peroxidase (556) is a modified form. Other properties of peroxidases (556) and (566) are being studied.

KUNIO TAGAWA
MASATERU SHIN
KAZUO OKUNUKI

Department of Biology,
Faculty of Science,
University of Osaka.
Oct. 18.

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Factors affecting the Rate of Bilirubin Conjugation *in vitro*

THE conjugation of bilirubin to its glucuronides in rat liver homogenates was studied, using boiled liver extract[1], uridine diphosphoglucuronic acid (UDPGA), uridine diphosphoglucose (UDPG) with diphosphopyridine nucleotide (DPN+), or the system consisting of uridine triphosphate (UTP) with glucose-1-phosphate (G–1–P), and diphosphopyridine nucleotide as sources of the glucuronosyl radical. The effects of various substances on the formation of bilirubin glucuronides from bilirubin are listed in Table 1. Under the conditions used in these experiments, liver homogenates hydrolysed 5·7 per cent of added phenolphthalein glucuronide (0·42 m*M*) in 30 min., this hydrolysis being inhibited (44·5 per cent) by 5·5 m*M* potassium glucuronate, and even more

Table 1. BILIRUBIN CONJUGATION AS EXPRESSED BY THE FORMATION OF PIGMENTS GIVING A DIRECT DIAZO REACTION

Incubation mixture (3·6 ml.) contained 0·75 µmoles of bilirubin, 20 mgm. of serum albumin, 166 µmoles of *tris*(hydroxymethyl)aminomethane, 30 µmoles of magnesium chloride, homogenate corresponding to 0·2 gm. of wet liver tissue, and other constituents indicated in the table. *p*H measured at the end of incubation of 90 min. at 37° C. in air. Blank values (homogenate at the end of incubation) were subtracted

Substance added (µmoles)								*p*H	Bilirubin conjugated (µmoles)	Percentage of bilirubin remaining at the end of incubation
UDPGA	UDPG	DPN+	UTP	G-1-P	Boiled extract corresponding to liver tissue in gm.	Glucuronate	Saccharate			
—	—	—	—	—	—	—	—	7·55	0·010	67·0*
2·0	—	—	—	—	—	—	—	7·50	0·098	75·0*
2·0	—	—	—	—	—	40·0	—	7·47	0·122	73·5*
2·0	—	—	—	—	—	—	4·0	7·40	0·125	71·5*
—	3·0	7·0	—	—	—	—	—	7·48	0·150	73·5†
—	3·0	7·0	—	—	—	40·0	—	7·48	0·188	70·0†
—	3·0	7·0	—	—	—	—	4·0	7·49	0·198	73·0†
—	—	9·0	6·0	25·0	—	—	—	7·40	0·027	34·5†
—	—	9·0	6·0	25·0	—	40·0	—	7·35	0·059	41·7†
—	—	9·0	6·0	25·0	—	—	4·0	7·40	0·064	34·8†
—	—	—	—	—	0·3	—	—	7·43	0·021	43·5*
—	—	—	—	—	0·3	40·0	—	7·46	0·031	43·5*
—	—	—	—	—	0·3	—	4·0	7·41	0·044	43·5*

* *p*H maintained with *tris* buffer, *p*H 7·5.

† Incubation started with 83 µmoles *tris*, *p*H 8·2 after 30 min. 83 µmoles potassium phosphate at *p*H 6·9 was added in order to reach *p*H 7·5.

(90 per cent) by 1·1 m*M* boiled potassium hydrogen saccharate. Both these substances exhibited marked enhancing effects on the formation of a fraction of bilirubin giving the direct van den Bergh diazo reaction. Bacterial β-glucuronidase (100 units) added to the incubation mixture almost abolished the bilirubin conjugation. The acceleration of this conjugation by glucuronate offers a plausible explanation for the effect of treatment of neonatal hyperbilirubinæmia with glucuronic acid[2]. Lathe and Walker[3] reported an inhibitory effect of glucuronate on the synthesis of bilirubin glucuronide in rat liver slices. The liver slices technique shows results different in some respects from those obtained with whole-liver homogenates. Grodsky *et al.*[4], working with liver homogenates, and with methods essentially similar to those described here, reported that no hydrolysis of 2 × 10^{-5} *M* phenolphthalein glucuronide occurred in their experiments, and that no activation of bilirubin conjugation could be observed with saccharate. Brown *et al.*[5], referring to the experiments of Karunairatnam *et al.* (see ref. 5) with liver slices, also deny that β-glucuronidase plays any part in producing hyperbilirubinæmia of the new-born. It has now been clearly demonstrated that in neonatal jaundice the deficiencies of glucuronosyl transferase[3–5] and of uridine diphosphoglucose dehydrogenase[5] are essentially responsible for the increase of serum bilirubin-levels. Ethylenediamine tetraacetate increased the production of bilirubin conjugates.

4-Methyl-1,4-naphthoquinone, and the corresponding hydroquinone inhibited the formation of bilirubin glucuronides at a concentration of 10^{-4} *M*. Both also showed inhibition of the uridine diphosphoglucuronic acid dehydrogenase action. Vitamin K_1 ('Konakion', Roche) had negligible effect on bilirubin conjugation even at a concentration of 10^{-3} *M*. Menadiol diphosphate ('Synkavit') did not inhibit under these conditions. In the experiments with whole-liver homogenates it even showed an activating effect on the production of pigments reacting directly but in much higher concentrations (10^{-3} *M*) than used by Lathe and Walker[3] with liver slices, and only at *p*H's above 7. The mechanism of oxidative phosphorylation described by Clark, Kirby and Todd[6] has been suggested as a possible explanation of this activating effect. The diphosphate ester, of course, cannot be supposed to resist dephosphorylation by tissues after the injection.

Detailed reports will be published elsewhere[7].

Thanks are due to Mr. A. Jelínek (of this Institute) for his valuable technical assistance; to Sigma Chemical Co. (St. Louis, Mo.) for help and generosity in supplying uridine diphosphoglucuronic acid, uridine diphosphoglucose, diphosphopyridine nucleotide, adenosine triphosphate, uridine diphosphoglucose dehydrogenase, bacterial β-glucuronidase, glucuronic acid, and cysteine hydrochloride; to Hoffmann La Roche Co. (Basle), and to Léčiva, n.p. (Modřany) for their gifts of vitamin K analogues.

E. TALAFANT
J. TOVÁREK

Department of Medical Chemistry,
Masaryk University,
Brno.
Sept. 25.

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Preparation and the Hæmoglobin Content of Red Cell 'Ghosts'

STUDIES of species differences in red cell phosphatides[1] have led to a re-examination of the problem of standardizing the method of preparing erythrocyte membranes ('ghosts', post-hæmolytic residues). It seems essential that if results obtained with physical methods, for example, electron microscopy, are to be correlated with those obtained by chemical analysis, greater uniformity of procedure for preparation of membranes must be sought. The matter has received little recent attention. In what was perhaps the first chemical analysis of the structural protein, stromatin, Jorpes[2] found his preparations to contain irregular amounts of hæmoglobin, representing 10–30 per cent of the dry weight. Not long afterwards, Adams[3] offered spectroscopic evidence for the idea that in the intact cell hæmoglobin is combined with stromatin. Keilin and Hartree[4], however, were able to show that the finding was explained by the peculiar optical properties of the medium and could not be regarded as an indication of a hæmoglobin–stromatin complex. Since that time the blood-pigment found attached to 'ghosts' has come to be regarded, or, at any rate, treated, as a sort of contaminant the physical association of which with the membrane proper interferes with obtaining satisfactory material for analysis of other things. Various methods have been devised for preparing 'ghosts', one of which[5] claims to reduce the iron content to the vanishing point ($<0 \cdot 01$ per cent hæmoglobin). It is difficult to find information about the stage in the processing at which the intact membranes begin to break up, or, indeed, what the microscopic appearance of the final product is. Usually, the recommended techniques introduce acid or salt washing at some point to expedite the removal of hæmoglobin—measures which in our hands have led to prompt disintegration of 'ghosts', as shown by microscopic examination.

As an approach to a standard method for preparing intact 'ghosts', human whole blood was first taken into acid–citrate–dextrose, which has proved so satisfactory an anticoagulant for blood banks. The plasma was removed by centrifugation and the cells washed three times in saline at 4° C. Lysis and a number of successive washings in ten volumes of cold water were then carried out. Portions of 'ghosts' so prepared were lyophilized for analysis in terms of dry weight.

A simple direct method of measuring hæmoglobin in the dry 'ghosts' was devised by taking advantage of the ability of strong urea solutions to dissolve many fibrous proteins while not interfering with the absorption spectra of hæmoglobin and its derivatives[6]. Weighed amounts of lyophilized ghosts were dissolved in 40 per cent urea containing standard cyanide–ferricyanide and the concentration of cyanmethæmoglobin measured in a photometer.

It could be shown after four washings with water that of the total hæmoglobin found initially in the intact cells about 3 per cent remained attached to the 'ghosts'. Eight further washings with water did not appreciably lower the hæmoglobin content. It was calculated both from the total pigment in the washings and from the measurements in dried 'ghosts' that the loss of 'attached hæmoglobin' after the fourth wash was about 5 per cent. Moreover, during the eleventh and twelfth washings the 'ghosts' were allowed to stand in the cold water overnight. The gross volume, as estimated after each centrifugation, remained throughout at about two-thirds of the original volume of wet, whole cells. Frequent microscopic examination showed that the red cell membranes remained intact disks. As a result of these findings the routine was adopted of washing four times with ten volumes of water.

Blood samples from 18 healthy and sick people (including one with sickle-cell disease) were examined, and the amount of hæmoglobin attached to the 'ghosts' was found to be 49–57 per cent of the dry weight (mean 54 per cent). The ratio of hæmoglobin nitrogen to non-hæmoglobin nitrogen was about 2 : 1 and the molar ratio of phospholipid to hæmoglobin about 15 : 1.

The finding of fairly constant amounts of hæmoglobin attached to the 'ghosts' is at variance with most reports both in quantity and in regularity. To the objection that the pigment could represent merely a denatured insoluble deposit, it may be said that one of the methods for preparing oxyhæmoglobin from intact cells involves principally exposure to cold water. Moreover, 'ghosts' suspended in water were equilibrated with nitrogen and showed the colour change to be expected with the formation of substantial amounts of reduced hæmoglobin ; this was reversed on shaking in air. For the moment it would seem reasonable to suggest that the finding of hæmoglobin in fairly constant amounts in 'ghosts' prepared as above supports the idea that the pigment is indeed a component part of the membrane. The distortions of sickle-cells under reduced partial pressure of oxygen also argue for such a view. It is difficult to understand the effects except in terms of hæmoglobin bound firmly enough to re-arrange directly the shape of the membrane.

The method described gives with human blood morphological reproducibility of intact 'ghosts' at the level of the ordinary microscope and chemical reproducibility for the few things so far studied : hæmoglobin, nitrogen and phosphatide. Studies are now being made to determine in how far the method is suitable for blood of other species.

This work has been supported by a grant from the U.S. Public Health Service (*RG*–5763–*C*) and a grant from the Avalon Foundation.

HELEN M. ANDERSON
JOSEPH C. TURNER

Department of Medicine,
Columbia University College of
Physicians and Surgeons,
and the Presbyterian Hospital,
New York.

Nov. 7.

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In vitro Synthesis of the Crown-Gall Tumour-inducing Principle

PREVIOUS research on crown-gall has shown that the transformation of normal plant cells into crown-gall tumour cells occurs in delimited stages involving specific causal agents[1].

Conditioning[2] requires several relatively simple compounds derived from the sap released by wounding the host. These include purines and possibly auxins[3], as well as other substances (Klein, unpublished work). Promotion requires auxin synthesized by the causal bacteria[4], from the incipient tumour cells[5], or from an external source. The nature of these auxins is under examination (Gentile and Klein, unpublished work).

The unique step in crown-gall formation is induction. This is normally accomplished by the action on conditioned cells of a tumour-inducing principle[6] synthesized by genetically competent bacteria[7]. Klein[8], Manigault *et al.*[9], Klein and Knupp[10], and Bender and Brucker[11], established that the bacteria synthesize the tumour-inducing principle, and succeeded in producing crown-gall in a variety of plants in the absence of the bacteria. Klein and Knupp demonstrated that the synthesis of the tumour-inducing principle *in vitro* was dependent on a synthesis factor present in wound juice. A survey of sources of the synthesis factor revealed that large amounts were present in malted barley[10]. The synthesis factor was extracted by salt solutions favouring the isolation of nucleic acids. When partially purified deoxyribonucleic acid from malted barley was added to a synthetic medium with 1 per cent sucrose as the carbon source, good growth of the bacteria and high titres of the tumour-inducing principle were obtained. Highly purified deoxyribonucleic acid from wheat germ was also a good source of the synthesis factor. By empirical substitution, the active material was found to be a pyrimidine, 5-methyl cytosine, its deoxyriboside, or its deoxyribotide, although thymine possessed slight activity.

Flasks of synthetic medium containing 5-methyl cytosine (100 μgm./ml.) were inoculated with log-phase cultures of *Agrobacterium tumefaciens* (strain B_6) and shaken for 24 hr. at 25° C. The culture medium was sterilized by centrifugation followed by filtration through a series of porcelain filter candles, and the filtrate treated with 3–4 volumes of 95 per cent ethanol. The resulting precipitate was dissolved in 0·2 *M* sodium chloride/0·01 *M* citrate, *p*H 7·0, and the solution dialysed overnight at 4° C. against the same buffer. It was reprecipitated with ethanol, dissolved in synthetic medium and sterilized by filtration. The procedure eliminated 'growth factors', including auxins, kinins, purines and pyrimidines, etc. Absorption spectra indicated that this purified tumour-inducing principle contained about 5 per cent nucleic acid by weight. The other major component was an acid polysaccharide which had no tumour-inducing principle activity. Further, the tumour-inducing principle activity of this purified preparation was abolished by deoxyribonuclease. The activity of the tumour-inducing principle was directly related to the known virulence of the strains of bacteria used, as well as to the concentration of the synthesis factor.

Treatment of properly conditioned disks of carrot phloem with purified tumour-inducing principle and subsequent promotion with auxin uniformly resulted in the formation of crown-gall tumours on the surface of all treated replicates (20–80 per cent variable). Time and temperature relations of this sterile induction are in conformity with the known course of tumour formation by bacteria *in situ*.

Details of this work are being prepared for publication elsewhere. It was supported by grants from the American Cancer Society and the Damon Runyon Memorial Foundation. Travel funds were supplied by the Rockefeller Foundation.

ALAN J. THOMAS*
RICHARD M. KLEIN

New York Botanical Garden,
New York, 58.
Oct. 15.

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* Permanent address: Department of Agricultural Chemistry, University College of North Wales, Bangor.

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Blood-clotting Activity of the Venom of *Bothrops jararaca*

THE well-known blood-clotting activity of the venom from snakes of various species of the genus *Bothrops* has been attributed to its proteolytic activity[1], although Michl[2] (using paper electrophoresis) and Holz and Raudonat[3] (using fractional precipitation with ammonium sulphate) have presented evidence against this point of view. The latter authors obtained a fraction, which they called "Koagulin", with a strong blood-clotting activity but only slight proteolytic activity when hæmoglobin was used as substrate. More recently, it has been shown that there exist at least two proteolytic enzymes in the venom of *Bothrops jararaca*: one of them is thermolabile[4] and is precipitated at 50 per cent saturation with ammonium sulphate[5], while the other is stable to heat[4] and is precipitated at 70 per cent saturation with ammonium sulphate[5]. The latter enzyme has been isolated in a fairly pure state and has been called *Bothrops* protease *A* (ref. 6).

We have studied some aspects of the coagulating activity of the venom of *Bothrops jararaca* and tried to separate the coagulating factor from the known proteolytic activities of the venom. We verified that the coagulating activity varies considerably with the buffer used. In 0·2 *M* cacodylate buffer the activity reached a plateau at *p*H 6·5–7·4 and was higher than in any of the other buffers used (acetate, phosphate, citrate, *tris* – maleate and *tris* – hydrochloric acid). In phosphate buffer at *p*H 7 or more the clotting activity is inhibited. In 0·05 *M* cacodylate, *p*H 7·0, the activity was totally preserved for two months if the preparations were kept in a vacuum flask at 1° C. The clotting activity was measured using 0·10 ml. of the sample to which 0·20 ml. of oxalated horse plasma was added; the zero time was noted and the mixture was gently agitated in a water-bath at 35° C. until a firm clot was formed. The samples were always previously diluted with an equal volume of 0·2 *M* cacodylate buffer, *p*H 6·50, so that the final reaction mixture was at *p*H 7·0.

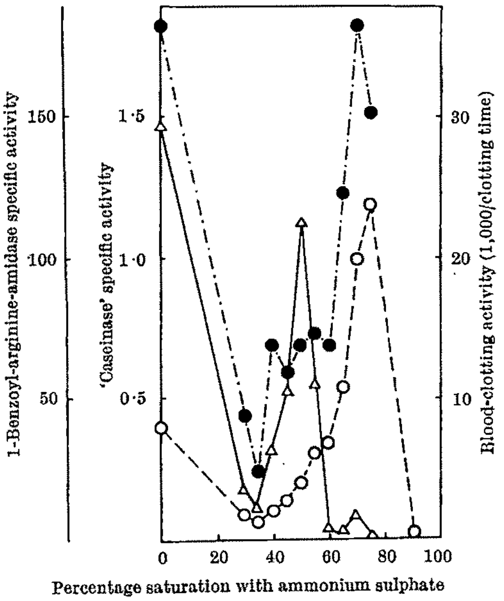

Fig. 1. Separation of protein fractions from *B. jararaca* venom by precipitation with ammonium sulphate: ○, 1-benzoyl-arginine-amidase activity; ●, blood coagulating activity; △, caseinase activity

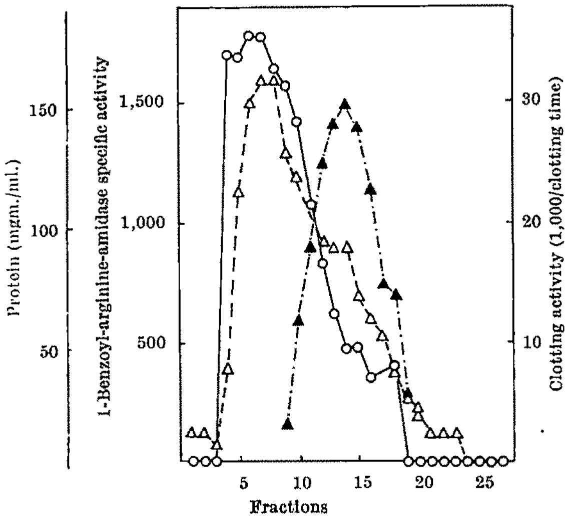

Fig. 2. Protein concentration, *Bothrops* protease *A* and blood-coagulating activities of fractions obtained by electrophoresis on a starch column of a crude preparation of *Bothrops* protease *A*. *Tris* buffer, pH 7·2, I 0·05. ○, 1-benzoyl-arginine-amidase specific activity; △, protein concentration; ▲, blood-coagulating activity

A 2 per cent solution of the venom in 0·05 M cacodylate buffer, pH 6·10 was fractionally precipitated with ammonium sulphate. The fractions obtained were dialysed against the same cacodylate buffer and assayed for 'caseinase'[6], 1-benzoyl-arginine-amidase and clotting activity; the latter was measured using the same amount of protein in all assays. The figures plotted in Figs. 1 and 2 were obtained by dividing 1,000 by the clotting time in seconds. As can be seen from Fig. 1 the peak of 'caseinase' activity separated between 40 and 50 per cent saturation with ammonium sulphate and the highest clotting activity was obtained in the fraction precipitated between 60 and 70 per cent saturation with ammonium sulphate. This fraction is probably identical with the "Koagulin" obtained by Holtz and Raudonat, although their coagulating fraction was precipitated at a lower level of saturation with ammonium sulphate. It can also be seen that the peak of 1-benzoyl-arginine amidase activity due to *Bothrops* protease *A* was found very near that obtained for the clotting activity, suggesting that the two activities were due to the same enzyme. We found, however, that electrophoresis on a starch column (Fig. 2) can separate these activities into two distinguishable peaks. It seems, therefore, that the clotting activity of *Bothrops jararaca* venom is neither related to its 'caseinase' nor to its *Bothrops* protease *A* content.

One of us (O. B. H.) is indebted to the Brazilian Research Council for a personal grant.

OLGA B. HENRIQUES
FAJGA R. MANDELBAUM
S. B. HENRIQUES

Laboratory of Biochemistry,
Instituto Butantan,
C.P. 65, São Paulo.

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Glutaminase Activity of the Fœtal Membranes and Kidneys of Pigs

AT a Ciba Foundation Colloquium on the effects of ageing on electrolyte metabolism, Widdowson and McCance[1] reported the pH of allantoic fluid to be between 5·5 and 6 at 46 and 67 days of gestation. Ammonia accounted for about 25 per cent of the "titratable acidity + ammonia" of these fluids. The total osmolar concentration of the allantoic fluid had been shown before to be only one-third to one-half that of fœtal serum at the same times of gestation, mainly due to the low concentration of sodium in the fluid[2]. When, therefore, Widdowson and McCance found that the acidity of allantoic fluid was largely due to high concentrations of carbonic acid, they suggested that active sodium re-absorption by hydrogen-ion exchange might be occurring in the fœtal membranes and kidneys. In support of this, they reported considerable carbonic anhydrase activity in the fœtal kidneys and membranes lining the allantoic sac.

The appreciable amounts of ammonia in allantoic fluid suggested that it might be worth searching for glutaminase activity in these fœtal kidneys and membranes, for this enzyme is probably the main source of the ammonia found in the urine of more mature animals[3,4].

Table 1. AMMONIA PRODUCTION BY FŒTAL MEMBRANES AND KIDNEY SLICES

Tissue	Average percentage of tissue water	mgm. of NH_3-N produced per 100 gm. of dry tissue per hour	
		Substrate added	No substrate added
46 days gestation			
Mesonephros	86·2	205 (3)	119 (2)
Metanephros	92·1	382 (2)	42 (2)
Amniotic membrane	93·6	344 (3)	74 (3)
Allantoic membrane	91·9	144 (2)	39 (2)
Chorioallantoic membrane	95·3	476 (2)	112 (3)
90 days gestation			
Kidney	91·2	383 (4)	72 (4)
Amniotic membrane	93·4	388 (7)	93 (7)
Allantoic membrane	87·5	219 (4)	82 (4)
Chorioallantoic membrane	95·0	304 (8)	117 (7)
Adult sow			
Kidney	87·5	256 (7)	82 (5)
Adult rat			
Kidney	82·2	548 (4)	49 (3)

No. of estimations (each in duplicate) in parentheses

This has accordingly been done. The kidneys and membranes were taken from pig fœtuses of 47 and 90 days gestation, the kidneys sliced as soon after death as possible and the tissues frozen and kept at − 18° C. For measurement of glutaminase activity, the weighed tissues were incubated in Warburg vessels at 37° C. in oxygen for exactly 60 min. both with and without added l-glutamine in 0·015 M concentration and the resulting ammonia determined. The technique in general resembled that of Robinson[5]. The results are shown in Table 1. For comparison, the amounts of ammonia formed by slices of renal cortex of adult pigs and rats are also presented.

It is evident that there is considerable glutaminase activity, not only in the fœtal mesonephros and permanent kidney, but also in all the fœtal membranes. There was also some ammonia formation in the absence of added glutamine. Fœtal membranes, therefore, contain the enzymes to which the acidity and ammonia found in urine formed by more mature animals are thought to be due. These enzyme systems may therefore play as active a part in the elaboration of the fluids which the membranes enclose as the fœtal kidney itself.

INGEBORG C. RADDE
R. A. MCCANCE

Medical Research Council
Department of Experimental Medicine,
University of Cambridge. Nov. 11.

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An Iodine Compound associated with Albumin in the Plasma of Thyrotoxic Patients

A RADIO-IODINATED protein, other than labelled thyroglobulin, has been found in the plasma of patients receiving radioiodine therapy for thyroid carcinoma[1]. Although this protein was associated with the albumin fraction of plasma protein, immunological techniques differentiated it from iodinated serum albumin[2]. The protein was detected after tracer doses of radioiodine (0·31–1 mc.) and was found only in malignant conditions[1].

Recently, however[3], an iodinated protein associated with the albumin fraction on electrophoresis was reported in the plasma of a cretin given a tracer dose of iodine-131. An earlier report[4], which seems to have been overlooked, described the presence of a fraction of activity, apparently protein, associated with serum albumin in the plasma of thyrotoxic patients receiving radioiodine therapy. It is the purpose of this communication to report confirmation of this latter finding, by another method of analysis.

In human plasma, thyroxine is carried by a specific protein forming a complex which on electrophoresis migrates to a position intermediate between α_1- and α_2-globulin[5]. In plasma examined after iodine-131 therapy, labelled thyroglobulin may also be found and must be distinguished from labelled thyroxine carried by its specific protein because they migrate to the same position between α_1- and α_2-globulin. If thyroxine is present in high concentration some will be carried by albumin, and this complex must be distinguished from iodinated protein of the same electrophoretic mobility. 20 μl. of plasma containing a little sodium thiosulphate were subjected to paper electrophoresis[6]. After drying at 100° C., the paper was passed through an automatic scanning device which recorded the positions of radioactivity on the paper. It was then stained with a solution of naphthalene black in methanol to locate the bands of protein, and washed in a solution of 10 per cent acetic acid in methanol. As this procedure completely removes thyroxine from its carrier protein, the activity remaining on the strip is assumed to be iodinated protein. Thyroxine labelled with radioiodine added to normal plasma can be completely removed from an electropherogram of the plasma in this manner, as can labelled thyroxine from electropherograms of the plasmas of those thyrotoxic patients in which no iodinated proteins are found. Plasma samples shown by electrophoresis to contain the albumin component also showed on chromatography a peak of radioactivity at the origin, presumably due to an iodinated protein.

Radioactivity associated with the albumin zone after staining has been found in the plasma of six of the thirteen thyrotoxic patients examined after the administration of therapeutic doses of iodine-131 (7–25 mc.). In three cases the albumin-like compound was the only radioactive component found after staining and washing the electropherogram. In three others radioactivity was associated with both albumin and thyroglobulin fractions, and in one of these the albumin component was detectable five days after treatment, by which time labelled thyroglobulin had disappeared.

CHRISTINA CAMERON
K. FLETCHER*

Medical Research Council,
Department of Clinical Research,
University College Hospital Medical School,
London, W.C.1.
Nov. 20.

* Present address: Medical Research Council, Experimental Radiopathology Research Unit, Hammersmith Hospital, London, W.12.

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Biological Activity of L-Tryptophan Esters

ROZENDAAL *et al.*[1] have shown that dry crystalline L-tryptophan, when irradiated with fast electrons at doses up to 10^9 r., is partially transformed into a complex mixture of compounds from which it is possible to obtain by chromatographic separation a fraction which inhibits the growth of certain bacterial species.

We have attempted the fractionation of the same irradiated material (given to us by Dr. H. M. Rozendaal, General Electric Research Laboratories, Schenectady) and have isolated from it several compounds. About 20 per cent of the original L-tryptophan is transformed by the radiation into a complex mixture of compounds, some of which are in the form of free radicals—as can be demonstrated by the paramagnetic resonance spectrum obtained from the irradiated tryptophan.

Separation of the mixture into its components is still incomplete, and the results on this aspect of the problem will be the subject of a future publication.

In addition to the fraction described by Rozendaal we have obtained a different one, which has led to the finding that some tryptophan esters are active as growth inhibitors for several micro-organisms. This fraction (*WS* 55) was consistently obtained by elution from an alumina chromatographic column with *n*-butanol saturated with 1 *N* hydrochloric acid. Fraction *WS* 55 was purified and obtained in crystalline form from hot water after clarification with active charcoal ('Nuchar' *C*–190–*N*).

This compound has been identified as the *n*-butyl ester of L-tryptophan by comparison of its physical and chemical properties with synthetically prepared material[2] (Table 1).

Once the chemical structure had been established, it appeared that this compound could be formed simply as an artefact of the chromatographic technique and therefore does not necessarily have to be

Table 1. Elementary Analysis

	WS 55	Synthetic compound	Theoretical for *n*-butyl ester of L-tryptophan hydrochloric acid
C	60·21%	60·98%	60·66%
H	6·97	7·06	7·07
N	9·54	9·59	9·43
O (by difference)	11·21	10·94	10·78
Cl	12·07	11·81	12·01
Melt. pt.	216–219° C.	216–219° C.	—
Molec. wt. (by neutral equivalent)	305	301	297

considered as a product of X-irradiation of L-tryptophan.

Inhibition by this ester was demonstrated on the following micro-organisms: *Escherichia coli* B, *Bacillus subtilis* 6051, *Streptococcus mastitidis* V_9, and on representative micro-organisms of the following genera (these organisms have been tested by Dr. W. T. Bradner of our Division): *Bacteroides*, *Butyribacterium*, *Clostridium*, *Micrococcus*, and *Proprionibacterium*. Details of the bacteriological data obtained with the first three organisms have been presented elsewhere[3].

A series of higher homologues of esters of L-tryptophan were synthesized[2] and tested for antibacterial activity employing as test organisms *E. coli* B, and *B. subtilis* 6051. Quantitative determinations for growth inhibition were performed in minimal synthetic liquid medium[4]. The level of inhibition was measured by determining the turbidity in a series of flasks at 560 mμ after 16 hr. incubation at 37° C.

It can be seen from Fig. 1 that as the length of the alcohol chain increases, the amount of ester required for 50 per cent inhibition of growth decreases. Furthermore, increasing the alcohol chain to more than eight carbons does not further increase the antibacterial activity. Moreover, the methyl and ethyl esters showed no inhibitory activity at concentrations as high as 2 μmoles/ml. A similar quantitative relationship has been observed for *B. subtilis* 6051.

A number of esters of other amino-acids have been synthesized or obtained commercially and several of these in preliminary experiments have shown inhibitory activity against the test organisms.

As yet the mechanism by which these amino-acid esters interfere with the growth of micro-organisms is unknown. It is tempting to speculate on the possibility that the esters may interfere with protein synthesis by virtue of the fact that, since they are in a chemically 'activated' state, they might combine more readily than their parent amino-acid with a 'carrier' and thereby flood the protein-forming system with primarily an over-abundance of a single type of 'utilizable amino-acid complex'. This may cause inhibition of growth due to synthesis of unbalanced proteins.

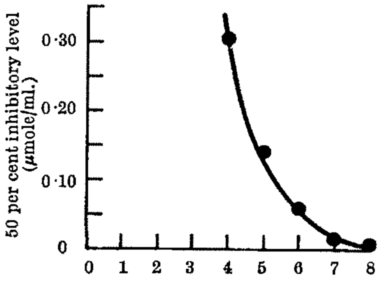

Fig. 1. Effect of alkyl chain-length of esters of L-tryptophan on the growth of *E. coli* B.

Giulio C. Perri
Louis Kaplan
C. Chester Stock

Division of Experimental Chemotherapy,
Sloan-Kettering Institute for Cancer Research,
and
Sloan-Kettering Division,
Cornell University Medical College,
New York.

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Detection of Sialic Acid in Various *Escherichia coli* Strains and in Other Species of Bacteria

It was recently reported[1] that an acidic aminopolysaccharide termed colominic acid was elaborated into the culture medium by the colocinogenic strain of *Escherichia coli* known as *K*235. This polysaccharide was afterwards shown to be composed of repeating units of *N*-acetylneuraminic acid or ovine sialic acid[2]. Since this was the first time that sialic acid substances had been found in other than mucopolysaccharides derived from mammalian sources a survey was made to ascertain whether these substances occurred in other *Escherichia coli* strains and in different species of bacteria. In addition, an attempt was made to correlate the pressure of sialic acid with other known properties of these bacteria.

A study of the agglutination properties of viable and heat-treated *Escherichia coli* $K235L+OC+$ bacteria in homologous antiserum revealed that this strain contains a capsule or envelope substance commonly termed a *K* antigen in addition to the somatic *O* antigen. Confirmation of the presence of a *K* antigen was obtained from agglutination experiments of viable bacteria in *K* antiserum.

The *Escherichia coli* $K235L+OC+$ strain was submitted for serological classification and showed the following serotype: *Escherichia coli* *O*1 : *K*1 : *HNM*. Several *Escherichia coli* strains of known serotype were analysed for sialic acid, bacteriocine and hæmolysin.

The bacteria were grown in sterile culture. The flasks, containing 500 ml. of suitable medium[2], were incubated with aeration at 37° C. for 5 hr. The bacteria were harvested by centrifugation. The cells were washed in 10 ml. of water and collected as before. The washed bacteria were suspended in 4 ml. of distilled water. The mixture contained in a sealed tube was heated for 2 hr. at 100° C. This procedure separated the *K* antigen from the bacterial surface. The bacteria were removed by centrifugation and the supernate decanted. Analyses for sialic acid were performed on this fluid by employing a modification of Werner and Odin's method[3].

The bacteria were tested for their ability to produce bacteriocine in the following manner. An overlay of nutrient soft agar seeded with *Escherichia coli* strain *B* bacteria was poured on to a stab culture of the organism grown on an agar plate and killed with chloroform. Presence of a bacteriocine inhibited the growth of the test organism, and a clear area about 2–3 cm. in diameter was visible around the killed stab

Table 1. *Escherichia coli* STRAINS TESTED FOR SIALIC ACID, BACTERIOCINE AND HÆMOLYSIN

Organism	Substance tested		
	Sialic acid	Bacteriocine	Hæmolysin
E. coli O1 : *K*1(*L*) : *HNM*	+	+	−
E. coli O6 : *K*53(*L*) : *HNM*	−	+	+
E. coli O20 : *K*17(*L*) : *HNM*	−	−	−
E. coli O10 : *K*5(*L*) : *HNM*	+	−	−
E. coli O4 : *K*12(*L*) : *HNM*	−	+	+
E. coli O21 : *K*20(*L*) : *HNM*	−	−	−
E. coli O11 : *K*10(*L*) : *HNM*	−	−	−
E. coli O8 : *K*44(*A*) : *HNM*	−	+	−
E. coli O9 : *K*29(*A*) : *HNM*	−	+	−
E. coli O9 : *K*55(*A*) : *HNM*	−	−	−
E. coli O9 : *K*35(*A*) : *HNM*	−	−	−
E. coli O9 : *K*38(*A*) : *HNM*	−	−	−
E. coli O9 : *K*33(*A*) : *HNM*	−	−	−
E. coli O26 : *K*60(*B*6) : *HNM*	−	−	+
E. coli O127*a* : *K*63(*B*8) : *HNM*	−	−	−
E. coli O86*a* : *K*61(*B*7) : *HNM*	−	−	−
E. coli O111 : *K*58(*B*4) : *HNM*	−	+	−
E. coli O112*a*, 112*c* : *K*66 (*B*11) : *HNM*	−	−	−
E. coli O55 : *K*59(*B*5) : *HNM*	−	−	−

culture. Hæmolytic properties were determined by streaking the culture on blood agar plates and noting whether the colonies were surrounded by a greenish ring or by a cleared area.

The results of all tests are given in Table 1. It is to be noted that of 19 strains examined only two give positive tests for sialic acid. The positive test obtained with the *Escherichia coli O*10 : *K*5 : *HNM* strain was weak. A quantitative evaluation of the amount of sialic acid released to the supernate by the heat treatment of cells of this strain showed but one-tenth of the amount of sialic acid found in a similarly treated sample of *Escherichia coli O*1 : *K*1 : *HNM* bacteria. These results indicate that sialic acid is not a common component of the various *K* antigens found in *Escherichia coli* bacteria.

It will also be seen from Table 1 that six of the *Escherichia coli* strains tested produce bacteriocine and that three produce hæmolysin. However, the presence of these properties is unrelated to the occurrence of sialic acid in the cells. Two strains tested, *Escherichia coli O*6 : *K*53 : *HNM* and *O*4 : *K*12 : *HNM*, show both bacteriocine and hæmolysin activities. Several strains which are devoid of hæmolytic activity elaborate bacteriocine. In addition, strain *O*26 : *K*60 : *HNM* shows potent hæmolytic properties but is a non-producer of bacteriocine. Thus, the hæmolysin and bacteriocine activities of *Escherichia coli* strains are unrelated to each other.

Several strains of *Escherichia coli* containing the *K*1 antigen but with different *O* antigens were examined for sialic acid, bacteriocine and hæmolysin. The results are recorded in Table 2. It is to be noted that all 5 strains tested gave positive tests for sialic acid. In addition, three of these strains produce bacteriocine and none produce hæmolysin.

Table 2. *Escherichia coli* STRAINS CONTAINING THE *K*1 ANTIGEN AND VARIOUS *O* ANTIGENS TESTED FOR SIALIC ACID, BACTERIOCINE AND HÆMOLYSIN

Organism	Substance tested		
	Sialic acid	Bacteriocine	Hæmolysin
E. coli O1 : *K*1 : *HNM*	+	+	−
E. coli O2 : *K*1 : *HNM*	+	+	−
E. coli O7 : *K*1 : *HNM*	+	+	−
E. coli O16 : *K*1 : *HNM*	+	−	−
E. coli O25 : *K*1 : *HNM*	+	−	−

Negative tests for sialic acid were obtained on the supernates isolated from several different species of heat-treated bacteria. These included 5 *Salmonella*, 7 *Shigella*, 1 *Pneumococcus* (Type 1), 3 *Megatherium* and 2 *Cereus* strains. A strain of *Citrobacter freundii* examined showed strong positive tests for sialic acid. The amount of sialic acid released by heating these cells was equivalent to that obtained from similarly treated *Escherichia coli* strains containing the *K*1 antigen. However, no serological relationship was found by cross agglutination tests between the *Citrobacter freundii* strain and the *Escherichia coli* strains containing the *K*1 antigen.

Therefore, the distribution of sialic acid among *Escherichia coli* strains containing *K* antigens is not widespread. Only 2 of the 19 strains tested indicate that sialic acid appears to form part of the chemical composition of the organism. Of the 77 known serologically different *K* antigens[4] associated with *Escherichia coli* bacteria, some 25 per cent were examined in this study. The richest source of sialic acid occurs in *Escherichia coli* strains which contain the *K*1 antigen. The existence of sialic acid in *Escherichia coli* strains is unrelated to the presence of bacteriocine or hæmolysin. Sialic acid was detected in only one other species of bacteria, namely, a *Citrobacter freundii* strain (*Escherichia coli* 5396/38).

This work has been supported by a grant from the U.S. Public Health Service.

I am indebted to Dr. W. H. Ewing of the Communicable Disease Center, Chamblee, Georgia, for the *Escherichia coli* strains and for the serological classification of *Escherichia coli K*235*L*+*OC*+.

GUY T. BARRY

University of Tennessee Memorial Research Center,
Knoxville, Tennessee.

Nov. 17.

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Urinary Excretion of β-Amino-*iso*butyric Acid in Eskimo and Indian Populations of Alaska

VARIOUS studies have shown that the differential urinary excretion of β-amino-*iso*butyric acid is under genetic control[1-4]. Family data indicate that a single major gene pair is responsible for most of the variation in differential excretion of β-amino-*iso*butyric acid, with high excretors being homozygous for a single recessive gene and low excretors either heterozygous or homozygous for the dominant allele. Further investigations have demonstrated marked variation in the frequency of high and low excretors in different races and have indicated the value of this character in genetical-anthropological work[5,6].

β-Amino-*iso*butyric acid appears to be derived from the breakdown of thymine via dihydrothymine and ureido*iso*butyric acid[7]. There is evidence that the differences in excretion-level may be due to differential metabolism of β-amino-*iso*butyric acid by low and high excretors[8].

In view of these considerations, it appeared possible that a comparative study of urinary excretion-rates of β-amino-*iso*butyric acid of Eskimo and Indian populations in Alaska might shed further light on the genetic relationship of these groups and on the selec-

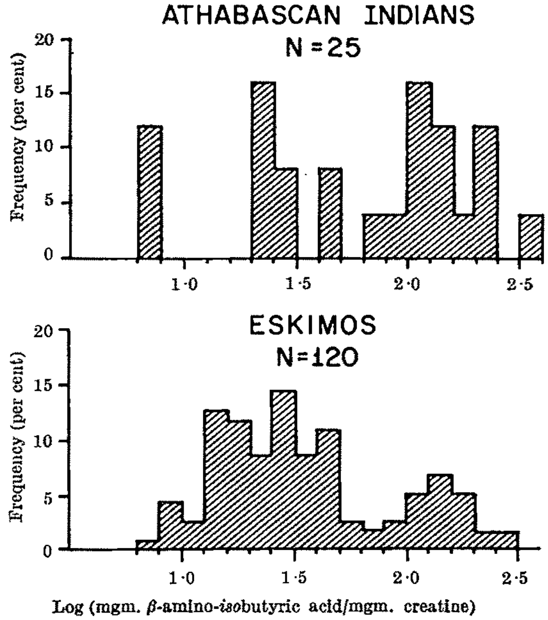

Fig. 1. Frequency distributions of urinary excretion-rates of β-amino-*iso*butyric acid of Athabascan Indians and Eskimos. *N*, number of subjects

tive forces which maintain this polymorphism in the population.

The populations studied were Eskimos from Barrow and Wainwright on the north coast of Alaska and Athabascan (Na-Dene)-speaking Indians from Fort Yukon, Beaver and Arctic Village. Further details of the population structure, which can be taken as randomly selected and nearly all pure-blooded (as indicated by census data), will be given elsewhere[9]. Urine specimens were collected in the field, thymol added as a preservative, and the samples kept at approximately 4° C. for 3–7 days until ready for shipment to the laboratory in Seattle. Determinations of β-amino-*iso*butyric acid were carried out by high-voltage electrophoresis on paper[10], and creatinine was determined by the alkaline-picrate method.

In Fig. 1, the frequency distributions of excretion of β-amino-*iso*butyric acid for the Athabascan Indian and Eskimo populations are presented. The frequencies are bimodally distinguished with the anti-mode at 1·85. Taking the anti-mode as the dividing point between low and high excretors, the frequencies of these classes can now be estimated, and the results, along with comparative values from other populations, are presented in Table 1.

The Alaskan Athabascan and Apache Indian populations show similar high frequencies for excretion of β-amino-*iso*butyric acid, whereas the Whites show a very low rate of excretion. The low rate of excretion for Whites has been well documented in other studies[1,2]. The incidence of high excretion of β-amino-*iso*butyric acid for North American Indians is given further support by some unpublished results of Kraus and Gartler on excretion of β-amino-*iso*butyric acid in the Papago and Pima Indians of Arizona, where values of more than 40 per cent high excretors were found. The excretion-rate of the Eskimo population is intermediate between the Indians and Whites, and differs significantly ($P < 0·01$) from that for the Alaskan Athabascans. The results then argue against any close genetic relationship of the Athabascan Indians and Alaskan Eskimos.

Table 1. Frequency of High Excretors in Various Populations

Population	Sample size	Percentage of high excretors
Alaskan Athabascan Indian	25	56·0
Apache Indian (ref. 4)	110	59·2
Alaskan Eskimo	120	23·3
New York Whites (ref. 3)	218	10·2

There is good evidence for a language affinity between the Apaches on one hand and the northern Athabascan-speaking people on the other[11], and some anthropologists have concluded that the Apache among others represent the southward migrated people from northern tribes[12]. Although the small numbers sampled preclude exact comparisons, the present results are consistent with such a relationship. Furthermore, if the similarity is borne out in more extensive studies, it would appear that there has been little change in the incidence of high excretors in two populations which are thought to have separated from each other 400–600 years ago[13].

It would be of interest to compare the Athabascan and Eskimo values with comparable results from various Oriental populations. However, at present only scanty and not strictly comparable results are available for some Chinese and Japanese groups[5,6]. The results show definitely higher excretion-rates of β-amino-*iso*butyric acid as compared with Whites, but are not sufficient to allow any conclusions regarding the origin of the Athabascan or Eskimo groups.

Collections of specimens in Alaska were facilitated by many individuals and agencies to whom we are indebted; in particular, Col. H. F. Currie, C. Murray and F. Milan of the Arctic Aeromedical Laboratory, Ladd Field; M. C. Brewer of the Arctic Research Laboratory, Barrow; Dr. Burns Jones of the Hudson Stuck Memorial Clinic, Fort Yukon; Drs. C. Dotter and C. Hopkins of the University of Oregon Medical School.

This work was supported in part by grants from the Wenner-Gren Foundation, U.S. Public Health Service (*H*-3161, *H*-3091 (C1)) and National Science Foundation (*G*-4464).

A. C. Allison
B. S. Blumberg
S. M. Gartler

National Institute for Medical Research, London,
and
National Institute of Arthritis and Metabolic Diseases,
National Institutes of Health, Bethesda, Maryland,
and
Department of Medicine, University of Washington,
Seattle.

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Effect of D-Sorbitol on the Absorption of Orally Administered Vitamin B_{12}

CHOW *et al.*[1] reported that a multiple component lipotropic elixir could increase the absorption of orally administered vitamin B_{12} by healthy subjects. It was afterwards claimed[2] that D-sorbitol was the substance in the elixir which possessed this quality, and radioactive studies in rats by Greenberg and his colleagues[3] supported these results. Morgan and Yudkin[4] produced experimental evidence suggesting that sorbitol could render rats independent of dietary sources of vitamins of the B group.

In view of these findings we have studied serial vitamin B_{12} values of the serum of twelve healthy subjects, who, for periods of 2 weeks or 3 months, took daily oral doses of vitamin B_{12} in water or in the form of a simple syrup, with or without D-sorbitol.

Serum vitamin B_{12} was estimated by the *Euglena gracilis* technique[5]. Each serum was tested three times. On one occasion all sera from each subject were assayed simultaneously. Methods of collection, storage and assay of sera were kept standard throughout. Normal range of serum vitamin B_{12} concentrations has been found[6] to be 130–750 μμgm. per ml. Unless stated otherwise, the daily dose of vitamin B_{12} or vitamin B_{12} and sorbitol was taken before breakfast.

Results to be reported elsewhere[6] show that there may be a physiological variation in the level of serum vitamin B_{12} in normal individuals taking a mixed diet. This was found to be up to 120 μμgm. per ml., and Chow *et al.*[7] have observed differences of even up to 216 μμgm. per ml. when repeating tests on normal subjects over 6–8 months.

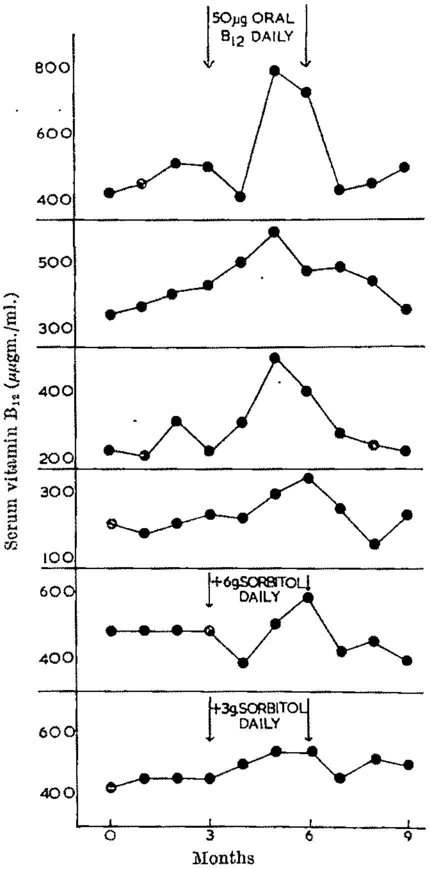

Fig. 1. Serum vitamin B_{12} values of six healthy subjects over a period of 9 months. Oral vitamin B_{12}, with or without additional sorbitol, was taken during the period indicated

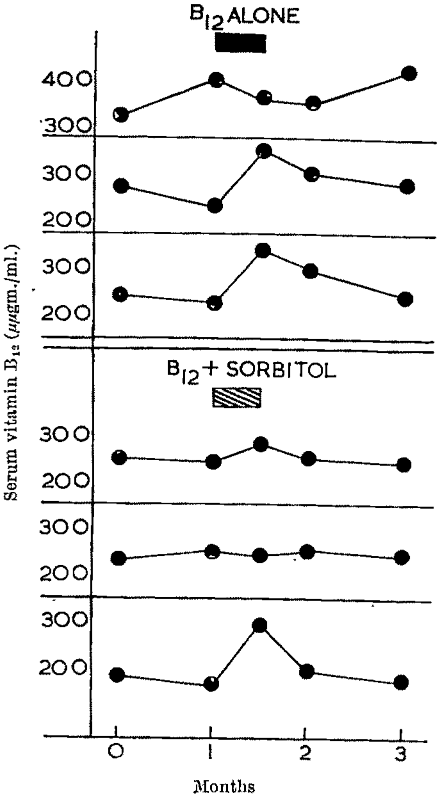

Fig. 2. Serum vitamin B_{12} values of six healthy subjects who received 25 μgm. vitamin B_{12} daily individual oral doses for 2 weeks, three with and three without the addition of 12 gm. sorbitol

As is shown in Fig. 1, two subjects taking either 6 or 3 gm. D-sorbitol daily with 50 μgm. vitamin B_{12} orally for 3 months showed no further increase in serum vitamin B_{12} level when compared with four individuals receiving 50 μgm. vitamin B_{12} in simple syrup.

Likewise, three subjects taking 25 μgm. vitamin B_{12} in water orally daily together with 12 gm. D-sorbitol in three divided doses for two weeks also showed no significant difference from the values obtained in three subjects taking the same dose schedule of vitamin B_{12} alone in water (Fig. 2).

12 geriatric patients without anæmia were given 50 μgm. vitamin B_{12} orally in syrup daily without D-sorbitol for four weeks. The mean serum vitamin B_{12} value of this group before the trial was 240 μμgm. per ml. (range 180–340). At the end of the four-week trial, all values had risen, giving a mean of 370 μμgm. per ml. (range 220–600). In a further group of six old people with a mean serum vitamin B_{12} level of 235 μμgm. per ml. (range 100–390) daily oral dosage of 50 μgm. vitamin B_{12} together with 6 gm. D-sorbitol for four weeks resulted in an increase to a mean serum vitamin B_{12} value of 340 μμgm. per ml. (range 190–540) at the end of the trial. These results, while showing that a rise in serum vitamin B_{12} concentration following such daily dosage can occur, give no support to the view that sorbitol, in the dosage given, increases absorption of vitamin B_{12} from the alimentary tract. Herbert[8] also found sorbitol to have no such effect in cases of pernicious anæmia.

We are grateful to those volunteers who co-operated in taking vitamin B_{12} orally in these studies.

J. N. MARSHALL CHALMERS
N. K. SHINTON

Department of Clinical Pathology,
Queen Elizabeth Hospital, Birmingham.

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Activation of Thionophosphates by Liver Microsomes

MANY organophosphorus insecticides are poor inhibitors of cholinesterase, but are converted to potent inhibitors ('activated') by certain mammalian and insect tissues. The activation by liver slices was first shown by Gardiner and Kilby[1] for schradan (a phosphoroamidate), and by Diggle and Gage[2] for parathion (a phosphorothionate). Davison[3] showed that both these activations could be effected by the combined soluble and microsomal fraction of liver, if magnesium, nicotinamide and diphosphopyridine nucleotide were provided. I have shown that the soluble fraction could be replaced by reduced diphosphopyridine nucleotide for activation of schradan[4] and malathion[5]. In the present work, a slightly different technique was used for demonstrating activation of phosphorothionate by liver microsomes with reduced diphosphopyridine nucleotide.

Once-washed microsomes were prepared as previously described[4] from a given volume of 10 per cent fresh mouse liver, and resuspended in the original volume of 0·9 per cent sodium chloride. To 0·5 ml. of this preparation was added 2×10^{-5} *M* organophosphate, 0·018 *M* magnesium, 0·01 *M* nicotinamide, and 1 mgm. pyridine nucleotide (usually reduced diphosphopyridine nucleotide), giving a total volume of 2·5 ml. The mixture was shaken for 30 min. at room temperature in a 50-ml. beaker (it was essential to expose a large surface area). Samples were then diluted 2, 20 and 200 times, and duplicate 1-ml. portions were added to 1·5 ml. of 7·5 times diluted human plasma, and incubated at 37° C. for 30 min. Acetyl choline bromide (0·2 ml. of 5 per cent) and 7·3 ml. of water were added and the cholinesterase activity determined by titrating to constant *p*H, using a micrometer syringe and a *p*H meter, with the sample at 37° C. being stirred by carbon dioxide-free air at 37° C.

In order to obtain a standard preparation, mouse microsomes were at first prepared in bulk (that is, from 20 gm. of liver), rapidly frozen in units sufficient for one day's work, and stored in the refrigerator. This treatment had previously been shown[4] to maintain activity, whereas under any other conditions activity disappeared in 24 hr. However, these frozen preparations deteriorated slowly, being inactive after eight days. Microsomes were therefore prepared fresh each day for the experiments reported here.

Table 1

Trivial name	Chemical name	Per cent cholinesterase inhibition: With microsomes	Per cent cholinesterase inhibition: Without microsomes
1. Co-ral	O,O-Diethyl O-(3-chloro-4-methyl-7-coumarinyl) phosphorothionate	89	10
2. Malathion	O,O-Dimethyl S-(1,2-dicarbethoxyethyl) phosphorodithioate	33	22
3. Guthion	O,O-Dimethyl S-(4-oxo-1,2,3-benzo-triaxinyl-3-methyl) phosphorodithioate	42	0
4. Diazinon	O,O-Diethyl O-(2-*iso*propyl-6-methyl-4-pyrimidyl) phosphorothionate	72	5
5. Potasan	O,O-Diethyl O-(4-methyl-umbelliferyl) phosphorothionate	85	26
6. 'Dimethoate'	O,O-Dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate	0	0
7. Trolene	O,O-Dimethyl O-2,4,5-trichlorophenyl phosphorothionate	43	0
8. EPN	O-Ethyl O-*p*-nitrophenyl phenylphosphorothionate	46	2
9. 'Tetram'	O,O-Diethyl S-(β-diethylamino) ethyl phosphorothiolate	50	47
10.	O,O-Diethyl S-(β-diethylamino) ethyl phosphorodithioate	93	18
11. Parathion	O,O-Diethyl O-*p*-nitrophenyl phosphorothionate	60	11
12.	Tetraethyl phosphorodiamidic anhydride	15	9

Pyridine nucleotide was reduced diphosphopyridine nucleotide. Figures are for organophosphates at 4×10^{-7} *M* (except 'Tetram', 4×10^{-9} *M*) at stage of incubation with cholinesterase. A different microsome preparation was used for each compound.

The results (Table 1) show activation of all compounds except 'Dimethoate' and 'Tetram'. The latter was included to test the possibility that dialkylaminophosphates might be activated: it appears that they are not. Microsomes can hydrolyse 'Acethion' (O,O-diethyl S-carboethoxymethyl phosphorodithioate) at the carboxyester group, and as a consequence do not show activation of 'Acethion'[6]. This may hold for 'Dimethoate' and (to a lesser extent) for malathion. The poor activation of tetraethyl phosphorodiamidic anhydride, compared with the strong activation of its methyl analogue, schradan[4], demonstrates that this system, which is so non-specific with phosphorothionates, is highly specific for certain phosphoroamidates.

The pyridine nucleotide requirement was also studied (Table 2). As in the activation of schradan[4], the reduced nucleotide is preferred; yet even the unreduced diphosphopyridine nucleotide shows clear activity; and reduced triphosphopyridine nucleotide is at least as good as reduced diphosphopyridine nucleotide.

This work shows that out of the ten thionophosphates studied (that is, the compounds of Table 1 except for Nos. 10 and 12), nine were activated by a preparation of microsomes and reduced diphosphopyridine nucleotide.

This communication has been approved for publication by the Director of the Wisconsin Agricultural

Table 2

Pyridine nucleotide	Per cent cholinesterase inhibition: Parathion 4×10^{-7}	Per cent cholinesterase inhibition: Parathion 4×10^{-8}
Nil	11	6
Diphosphopyridine nucleotide	60	9
Reduced diphosphopyridine nucleotide	100	39
Triphosphopyridine nucleotide	39	28
Reduced triphosphopyridine nucleotide	100	56

Systems contain 1 mgm. per flask of pyridine nucleotide indicated. Concentrations given are for parathion or products at stage of incubation with cholinesterase. All results are from the same microsome preparation.

Experiment Station. The experiments were performed by Mr. V. K. Patel, and the study was supported in part by funds from the Wisconsin Alumni Research Foundation.

R. D. O'BRIEN

Department of Entomology,
University of Wisconsin.

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BIOLOGY

A Sex Difference in Radioactivity of *Artemia* cultured in Sea Water containing Phosphorus-32

PHOSPHORUS as a constituent of energy storage-transfer systems and as a structural component of nucleic acid is essential to life. As such it is not surprising that its radioactive form has proved to be the isotope of greatest biological importance in the disposal of liquid wastes from atomic energy installations[1]. The present report concerns a phase of a long-term investigation on the genetic effects of radiation on populations of marine animals.

During the summer of 1958, phosphorus-32 was added in known concentration to sea water containing adult brine shrimps, *Artemia salina*. Afterwards, Geiger–Müller counts were made of individual adults and of samples of the sea water. Over a significant period of time, females were more radioactive than males.

An American diploid amphigonic strain of *Artemia* has been maintained in jar cultures for 4 years. Similar cylindrical jars, 27 cm. × 15·6 cm., were used for the present experiment. Thirty pairs of adults were placed in 3 litres of sea water. Then 30 μc. of phosphorus-32 was added. The chemical form was hydrogen phosphate in dilute hydrochloric acid solution. Adults were removed periodically, washed thoroughly in sea water, killed and dried, one per planchette. At the same time, a sea-water sample equivalent in mass to an *Artemia* was also dried on a planchette. A measure of the radioactivity was then obtained by counts taken with an El-Tronics, Inc. Scintillation Scaler, Model *LS*6455, using a shielded manual sample changer, Tracer Lab., Inc. Model *SC9E*.

In the first experiment, the relative radioactivity of sea water and of a single male and female was assessed nearly every day for a 20-day period. The results demonstrated early achievement of a high peak in female radioactivity and a levelling off for both sexes at about the tenth or eleventh day, by which time uncentrifuged sea water showed little radioactivity above background.

A second experiment was then set up to provide at least two animals of each sex to be counted each day for 15 successive days. Results are summarized in Fig. 1. The radioactivity of females was consistently above that of males until nearly two weeks had elapsed. Although they were already more radioactive than centrifuged sea water after one day, *Artemia* did not surpass the radioactivity of uncentrifuged sea water until 3 or 4 days. This is taken as evidence of the transfer of radiophosphorus through the food-chain. Uncentrifuged water contained *Chlorella*, bacteria and yeast cells. The latter are added to the culture as a diet supplement in amounts of 3 drops of dilute suspension per day.

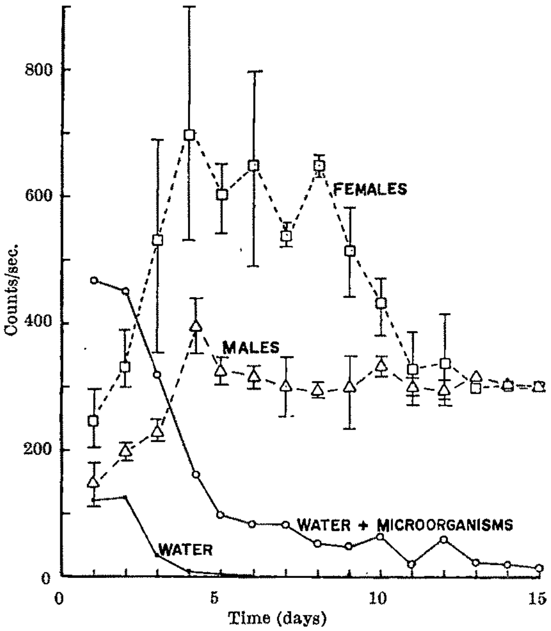

Fig. 1. The relative radioactivity of *Artemia* and the sea water in which they were maintained after a single addition of phosphorus-32 on day zero. The limits shown are the extreme low and high values for each day

In order to determine what happens during the first 24 hr., a third experiment was set up in which individuals were killed every hour for the determination of radioactivity. A sharp threshold was found between 9 and 10 hr. Before this, all animals were low in radioactivity; after this they were highly radioactive. This corroborates that radiophosphorus association with *Artemia* is through ingestion as food rather than through adsorption or absorption. The period of time between addition to the culture and appreciable radioactivity of brine shrimp may reflect time required for biosynthetic incorporation by the micro-organisms.

A peak and decline of female radioactivity (Fig. 1) may be explained by loss of phosphorus-32 through incorporation into offspring. At least one F_1 group was produced by the adults during the period of Fig. 1. Furthermore, on the basis of a brood every 4½ days[2], females considered after the ninth day could already have given birth to two broods, thereby dispersing radiophosphorus into 30–140 offspring. Since the *Artemia* life-span averages 4 months[2] while the half-life of phosphorus-32 is only 14·3 days, detection of a re-occurrence of the sex difference due to re-cycling of phosphorus-32 seems unlikely.

In the wasp *Habrobracon*, Grosch and Sullivan[3] showed that 60 per cent of a radiophosphorus meal fed to females was deposited in the eggs. Also, measured in terms of dominant lethals, the same meal is much less potent if fed to males[4]. In houseflies, females of two strains became more radioactive than males[5]: in two species of *Drosophila*[6] turnover of phosphorus-32 differs between males and females, and female mosquitoes become twice as radioactive as males[7]. Since exceptionally high turnover of phosphorus associated with oviposition also characterizes laying hens[8], the phenomenon is not limited to the phylum Arthropoda.

In radio-ecological studies it has been customary to consider season, development and age for members of various species[9]. Present results suggest that sex is also a matter of importance. The degree of induced sterility and zygotic dominant lethality now under study is otherwise unexplained.

DANIEL S. GROSCH

Department of Genetics,
North Carolina State College,
Raleigh, North Carolina.

MARY ELLEN PLUMB*

Marine Biological Laboratory,
Woods Hole, Massachusetts.

* Research Assistant supported by the U.S. Atomic Energy Commission.

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A Correlation between Iodine Permeability and the Gram Characteristic of Cells

Kaplan and Kaplan[1] demonstrated that the addition of iodine to the alcohol used as a decolorizer in the Gram procedure resulted in retardation of the rate of decolorization. If the concentration of iodine was sufficiently high, no decolorization occurred. They also found that much higher concentrations of iodine in the alcohol were necessary to prevent the decolorization of Gram-negative bacteria than for Gram-positive bacteria. In their opinion these results indicated that differences in permeability to iodine in alcoholic solution contributed to the mechanism of Gram differentiation. In confirmation of the above work, Mittwer, Bartholomew and Kallman[2] demonstrated that iodine in alcoholic solution stained Gram-negative cells much faster than Gram-positive cells. No such difference was demonstrable for iodine in aqueous solutions. The nature of the proof presented by the above workers, however, lacked accurate and objective results, and could not be considered as conclusive. When the methods of filter paper chromatography are applied to this problem, accurate and objective results can be obtained easily.

The chromatographic apparatus used consisted of 8 in. × 1¼ in. glass test-tubes with cork stoppers. 8 ml. of solvent were placed in the bottom of the tubes. A cut was made in the bottom of the cork with a knife. The top of a filter paper strip (7¼ in. × ¾ in., Whatman No. 1) was inserted into the cut. The cork and filter paper assembly were then inserted into the test-tube. This resulted in the bottom ¼ in. of the filter paper being immersed in the solvent.

Cell suspensions were prepared by harvesting the cells from a 48-hr. Petri-dish culture in 5 ml. of sterile water. Nutrient agar was used for bacterial cells, and wort agar for yeast cells. The suspension was transferred to a test-tube and centrifuged. Following centrifugation the supernatant was decanted, and 3 ml. of Gram's iodine solution added. The cells were resuspended in the iodine solution for 5–10 min., and then recentrifuged. The supernatant was drained off. The cell paste remaining was then used in the experiments. Approximately 0·005 ml. of this paste was deposited in a thin line across the width of the filter paper, at a distance of about 1 in. from the bottom. Sahli pipettes (0·02 ml. volume) were found useful for this purpose. The preparation was allowed to dry for about 1 hr. Occasionally, when the cell paste was too thick, the cells would separate from the filter paper during the drying period. This could be prevented by thinning the cell paste in the test-tube by adding one drop of iodine solution and afterwards washing the free iodine from the filter paper – cell preparation by the following method. After drying, the lower end of the filter paper carrying the cells could be immersed in 96 per cent alcohol in a series of 3–5 Coplin jars for 1 min. in each jar. This effectively removed free iodine from the filter paper but left sufficient in the cells for the purposes of the experiments. After drying, the filter paper strips were then placed in the chromatographic apparatus containing 8 ml. of solvent. After 1 hr. the strips were removed, dried, immersed in 0·5 per cent aqueous starch solution, dried with blotting paper, then air dried. The distribution of iodine was indicated by the blue colour.

The Gram-positive organisms used were *Saccharomyces cerevisiae*, *Staphylococcus aureus* and *Sarcina lutea*. The Gram-negative organisms used were *Escherichia coli*, *Proteus vulgaris* and *Pseudomonas fluorescens*. Fig. 1 shows the results for two Gram-positive (*A*,*B*) and two Gram-negative (*C*,*D*) organisms. The cells treated with iodine were exposed to 96 per cent alcohol as a solvent in the chromatographic apparatus. The difference in loss of iodine between Gram-positive and Gram-negative organisms could be seen visually before the strips were immersed in the starch solution. The starch solution was used in an attempt to aid photographic representation of the results obtained. In some instances no detectable iodine left the Gram-positive cells, as compared with a plentiful and continuous loss of iodine from Gram-negative cells. In other instances the loss of iodine from the Gram-positive cells was sufficient to give a very faint blue colour with starch, as com-

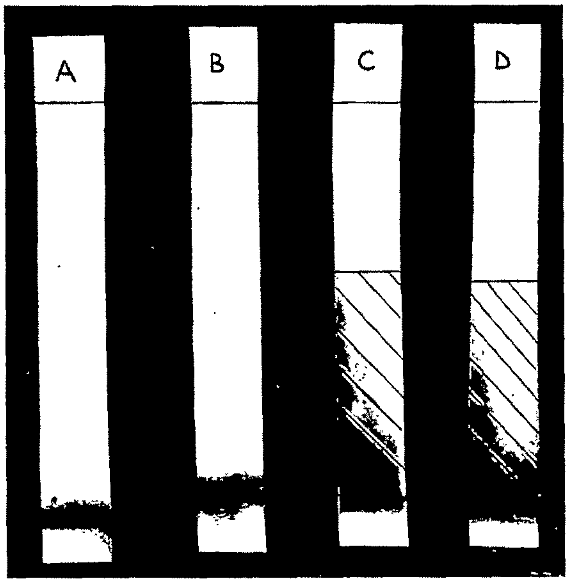

Fig. 1. Cells treated with iodine, then exposed to 96 per cent alcohol as the solvent in a chromatographic apparatus. *A*, *Saccharomyces cerevisiae* ; *B*, *Staphylococcus aureus* ; *C*, *Escherichia coli* ; *D*, *Proteus vulgaris*. A 0·5 per cent aqueous starch solution was used to aid in the photographic demonstration of iodine distribution. During exposure to aqueous starch the thick blue line at the base of the strips appeared due to iodine diffusion out of the cells (strips *A*, *B*). The top line represents the height reached by the solvent, the cross-hatching the area of deep blue colour

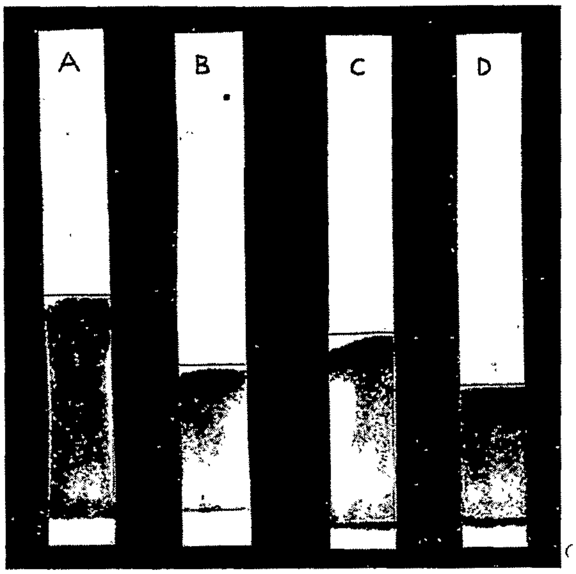

Fig. 2. Same as Fig. 1 except that filter paper strips were exposed to 0·5 per cent aqueous starch solution as the solvent in the chromatographic apparatus

pared with a very deep blue colour given when Gram-negative cells were used. No exceptions to these differences were found during repeated testing of three species of Gram-positive organisms and three species of Gram-negative organisms. Fig. 2 shows a similar series of filter paper strips, except that aqueous starch solution was used as a solvent in the chromatographic apparatus. It can be seen that under aqueous conditions the iodine left both Gram-positive and Gram-negative cells at a very rapid rate. This difference between alcohol and aqueous solvents and their effect on loss of iodine from bacterial cells confirms the observations of Mittwer, Bartholomew and Kallman[2]. If filter paper strips with organisms were first placed in the chromatographic apparatus for 1 hr. with 96 per cent alcohol as a solvent (or washed in alcohol by the procedure given above), then dried and again placed in the apparatus with aqueous starch solution as a solvent, results were obtained identical with those shown in Fig. 2. This demonstrated that exposure to alcohol under these conditions left considerable residual iodine in the cells. The differences shown in Fig. 1, therefore, represented differences in the rate of loss of iodine.

The above results show clearly the difference between Gram-positive and Gram-negative organisms in the rate of iodine loss when alcohol is used as a solvent. We are now trying to obtain better quantitative results by using radioactive iodine. It is yet to be demonstrated whether the above differences are responsible for Gram differentiation or merely correlated with it.

This work was assisted by a grant (*E*-121) from the Institute of Allergy and Infectious Diseases, National Institutes of Health, U.S. Public Health Service.

J. W. BARTHOLOMEW*
THOMAS CROMWELL
HAROLD FINKELSTEIN

Department of Bacteriology,
University of Southern California,
Los Angeles 7. Oct. 31.

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* 1958–59 Fulbright Lecturer, Department of Bacteriology, School of Medicine, University of Queensland, Brisbane, Australia.

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Dependence of the Heat Resistance of Bacterial Endospores on their Dipicolinic Acid Content

IT is generally accepted that mature spores from aerobic or anaerobic bacteria contain large quantities (5–15 per cent of the dry weight) of dipicolinic acid, whereas it is absent in the non-resistant vegetative cells[1,2]. Biosynthesis of dipicolinic acid is usually considered to be indicative of the formation of heat-resistant spores. In *Clostridium roseum*[3] sporulation involves the development first of a refractile spore-like body, which is followed by the synthesis of dipicolinic acid, and later of a heat-resistant spore. In the aerobic bacteria, however, a close correlation between these three processes makes difficult the isolation of the first stage in sporulation.

In collaboration with Dr. George Cohen, we have been studying the route of the biosynthesis of dipicolinic acid in *Bacillus cereus* var. *terminalis* by isotopic competition experiments. During the course of these studies, it was observed that the presence of phenylalanine during sporulation reduced the level of dipicolinic acid formed. These findings have led us to examine further the specificity of this suppression and the relationship between the dipicolinic acid content, viability and heat resistance of the free, mature spore.

Spores of *B. cereus* var. *terminalis* were produced in 100-ml. flasks containing *G* medium[4] supplemented with various amino-acids. The flasks were shaken aerobically at 30° C. until lysis of the vegetative cells had proceeded to the point where the culture contained more than 90 per cent free spores. The spores were first separated from the vegetative debris by centrifugation at 1,500 r.p.m. for 1 hr. in a solution of higher specific gravity (40 per cent sucrose). The spores were then further cleaned as previously described[4]. The washed spores were lyophilized and their dipicolinic acid content determined on a 15–20 mgm. sample by the method of Janssen *et al.*[5]. To measure heat resistance, an aqueous suspension (1 mgm. spores/ml.) was heated to 80° C. and aliquots removed at intervals for measurement of viability.

The results in Table 1 show that the dipicolinic acid content of spores is lowered from 74 to less than

Table 1. EFFECT OF THE COMPOSITION OF THE SPORULATION MEDIUM ON THE PROPERTIES OF THE SPORE

Growth supplements*						Amino-acid	Dipicolinic acid (μgm./mgm.) of day spores	Viability (per cent)	*K*†
YE	*P*	*T*	*F*	*R*	*B*				
200	—	—	—	—	—	—	74·1	100	0·76
20	—	—	—	—	—	—	49·2	93	1·30
2	—	—	—	—	—	—	5·4	56	2·25
0·2	—	—	—	—	—	—	< 0·2	34	8·88
0·2	60	15	—	—	—	—	32·3	100	1·65
0·2	60	15	10	—	—	—	34·6	83	1·62
0·2	60	15	10	15	—	—	12·2	100	2·08
0·2	60	15	10	15	9	—	< 0·2	21	3·39
2·0	60	15	—	—	—	—	77·3	100	0·69
2·0	60	15	—	—	—	DL-Phenylalanine	0·6	46	2·61
2·0	60	15	—	—	—	DL-Alanine	78·0	100	0·69
2·0	60	15	—	—	—	DL-Valine	77·7	80	0·64
2·0	60	15	—	—	—	DL-Lysine	80·0	94	0·64
20	60	15	—	—	—	DL-Glutamic acid	61·8	93	1·06

* Abbreviations: *YE*, yeast extract; *P*, pantothenic acid; *T*, thiamine; *F*, folic acid; *R*, riboflavin; *B*, biotin.

The following additions were employed: *YE*, mgm./100 ml. *G* medium; vitamins, μgm./100 ml. *G* medium; amino-acids were added at 200 mgm./100 ml. *G* medium.

† Calculated from equation $K = \frac{1}{t_2 - t_1} \log \frac{N_1}{N_2}$, where t is time of exposure at 80° C. in min.

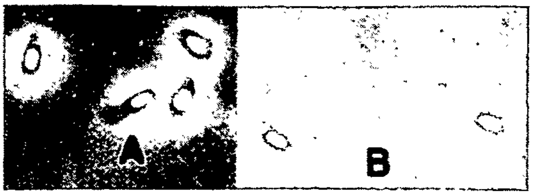

Fig. 1. Spores of *Bacillus cereus* var. *terminalis*, produced in the presence (*A*) or absence (*B*) of 1 mgm./ml. DL-phenylalanine (× 1,000)

0·2 μgm./mgm. spores by reducing the level of yeast extract in the sporulation medium. The dipicolinic acid content is raised by the addition of vitamins, suppressed by the addition of DL- or L-phenylalanine and relatively unaffected by the presence of various other amino-acids. The inhibition of the synthesis of dipicolinic acid by phenylalanine was not reversed by increasing the level of yeast extract.

With the possible exception of spores produced in medium containing 0·2 mgm. yeast extract/100 ml. medium without added vitamins, variation in the dipicolinic acid content is not reflected in the appearance of the spore. As shown in Fig. 1, spores grown in L-phenylalanine are indistinguishable from spores grown in *G* medium. In all cases the spores were refractile and impermeable to methylene blue. Germination and resporulation in *G* medium of spores low in dipicolinic acid yielded spores with a normal dipicolinic acid content.

Fig. 2 shows the relation between dipicolinic acid content, viability and the rate of heat inactivation of the spores in Table 1. Above 1·2 per cent dipicolinic acid, viability is independent of the dipicolinic acid content; however, as the level of dipicolinic acid is reduced below 1·2 per cent, the proportion of non-viable, spore-like bodies increases. The rate of heat inactivation shows a biphasic dependence on dipicolinic acid content. It thus appears that dipicolinic acid protects at least two sites of the spore against heat inactivation.

Although the ubiquitous presence of dipicolinic acid in mature bacterial spores has led to some speculation on its role in regulating the metabolic activity of the spore[6], little information is available on the function of the acid in heat resistance. Clearly, further information on the state of dipicolinic acid in mature spores and correlations between the contents of that acid and divalent metals and heat resistance is necessary to clarify the function of the acid. Although the present experiments have demonstrated a dependence of heat resistance on the acid content, attempts to protect enzymes in spore extracts against heat inactivation with dipicolinic acid have thus far had negative results[2].

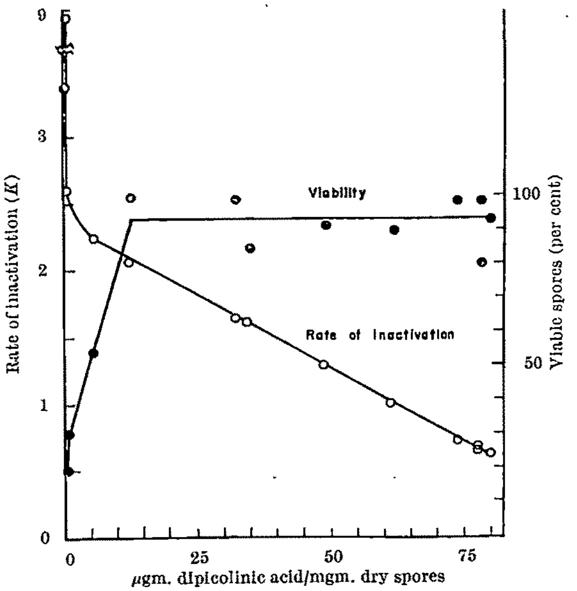

Fig. 2. Effect of the dipicolinic acid content on the viability and heat resistance of bacterial spores

Work is in progress to examine the physiology of spores with low dipicolinic acid contents.

We wish to acknowledge support from the Wisconsin Alumni Research Foundation and the Research Institute of the Warner-Lambert Pharmaceutical Company.

BROOKS D. CHURCH
Warner-Lambert Pharmaceutical Co.,
Morris Plains, N.J.

HARLYN HALVORSON
Department of Bacteriology,
University of Wisconsin,
Madison, Wisconsin.

Oct. 18.

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Genetic Independence of Four Mutants in the Syrian Hamster

GENETIC tests have been completed for possible linkage between the four mutant alleles, ruby-eye (*ru*) and cream[1] (*e*), acromelanic albinism[2] (c^d) and piebald spotting[3] (*s*), of the hamster *Mesocricetus auratus*. Each of the ten possible combinations with four genes, and with the sex-differentiating segment of the *Y* chromosome treated as a dominant gene, has been studied.

Only one of the ten combinations yielded a disturbed genic segregation which could possibly be interpretated as linkage. The two mutants concerned are *ru* and *s*, and the disturbed segregation, which is a repulsion F_2, is as follows:

RuS	*ruS*	*Rus*	*rus*	Associative χ^2
684	172	87	8	7·59

However, the two genes are known individually to confer a semi-inviability, and the observed figures could also be interpreted as due to an inviability interaction resulting in excessive mortality of the *rus* class. An indication that such an effect could be operating is given by an analysis of variance of 21-day weight of the F_2 generation, which revealed significant differences between the four classes. Taking the normal class as standard, the percentage weights of the following three are 83, 77 and 45. If the respective weight reductions for the presence of *ru* and *s* are independent, the combined reduction would be expected to be of the order of 64, rather than 45, per cent.

The two interpretations may be effectively distinguished by the joint consideration of two F_2's, one in repulsion and the second in coupling phase. The production of the second F_2 necessitates breeding from *ruruss* animals, and this is complicated by the

Table 1

Phase	*RuS*	*ruS*	*Rus*	*rus*	Associative χ^2
Coupling	153	37	24	1	3·64
Repulsion	150	40	23	1	3·92

impaired fertility of *ruru* males[1,4] and small size and weakened maternal instincts of *ruruss* females. No *ruruss* males have been found to be fertile; but, by persevering with *ruruss* females, suitable F_1 young were reared, which produced the F_2 of Table 1 (first row).

The number (215) constituting the coupling F_2 is too few to balance adequately the much larger original repulsion F_2, so the first 55 litters from the latter, comprising 214 young, were extracted (Table 1, second row). The two distributions agree closely, and it may be inferred, therefore, that the disturbed segregation of *ru* and *s* is not due to linkage but to an inviability interaction. A maximum likelihood analysis for departure from random assortment is presented below. The total score (3·14) represents a negligible deviation.

Phase	Score	Information	χ^2
Coupling	46·506	576·369	3·70
Repulsion	−49·650	628·931	3·92
	−3·144	1,205·300	0·01

A summary of results for the remaining nine combinations is presented by Table 2. The *ru-Y* comparison just attains a significant value of χ^2 but further analysis suggests that this may either represent a small inviability interaction, such that the male *ruru* is less viable than female *ruru*, or be due to a not improbable chance deviation occurring among a number of sub-sets of data.

Table 2

Mutants	Score	Information	χ^2
e-ru	−73·333	3,168·591	1·69
e-s	17·111	1,281·912	0·24
e-c^d	20·889	930·962	0·47
e-Y	−28·000	3,254·208	0·24
ru-c^d	−24·988	938·183	0·66
ru-Y	−113·333	3,331·970	3·85
s-c^d	− 12·813	138·012	1·19
s-Y	10·667	1,028·423	0·11
c^d-Y	62·000	2,793·333	1·38

No evidence for linkage is apparent from these results. The Syrian hamster has 22 chromosomes, and an idea of the probability of finding at least one linkage with 4 mutant genes among 21 autosomes may be computed by Green's method[5]. The probability is merely 26 per cent. The number of mutants required for the probability of linkage to exceed that of no-linkage is 6, but the probability (54 per cent) is not high. Of the residual probabilities, only that for a single linkage is appreciable (43 per cent). It may be concluded that the discovery of many more mutant genes is necessary before the chance of linkage detection in the hamster tends to approach certainty.

ROY ROBINSON

St. Stephens Road Nursery,
Ealing, London, W.13.
Nov. 5.

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Control of Diapause by an 'Internal Clock' in *Anthrenus verbasci* (L.) (Col., Dermestidae)

THE life-history of this carpet beetle under outdoor conditions in southern England is as follows. Adults emerge in June and July and may be found on many species of creamy-white flowers, notably cultivated *Spiraea* spp. and *Heracleum sphondylium* L. (hogweed). One of the main oviposition sites is dry birds' nest material found in the attics of buildings. Eggs hatch in about five weeks, but larvæ may require two years for complete development. Pupation occurs in early May, and lasts about a month; after a further week of inactivity the active adults emerge. When mating occurs immediately, eggs are laid from about one week onwards for at least a month. Adults die about the end of July. Experiments on the development of larvæ under outdoor conditions showed a clear annual rhythm of activity, namely, a rapid rate of moulting during the summer (May–August) and rest during the winter.

A striking feature of the development of this species, and one which, so far as I can discover, has not previously been demonstrated for an annual rhythm in any animal, is that this cycle of active growth and rest persists when development takes place under constant physical conditions in the laboratory. When larvæ were reared at constant temperatures of 15·0–25·0° C., the frequency distribution of times of pupation was clearly bi-modal (Fig. 1). Larvæ which pupated in the first group had only one period of diapause and their development was completed in a single one-year cycle, but those which pupated in the second group had two periods of diapause and followed a two-year cycle. The proportion of individuals taking one or two years to complete development was dependent upon the temperature (Fig. 1).

There was alignment of the active periods of individuals at different temperatures. During the first active period, which followed immediately after emergence from the egg, the increase in size was roughly proportional to the temperature. Consequently, at the end of the first active period larvæ developing at 15·0° C. were only small, while those

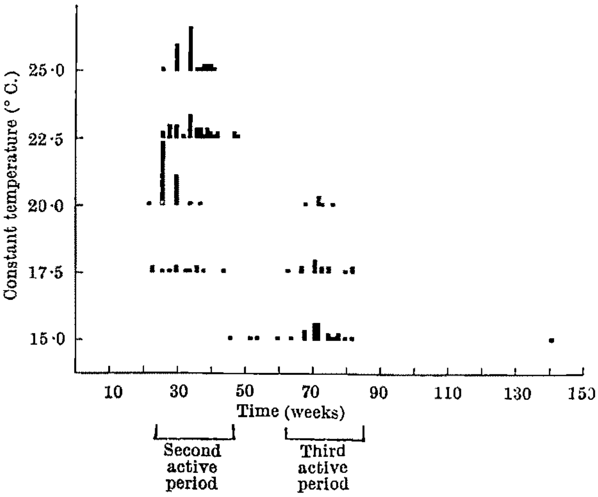

Fig. 1. Frequency of pupation times when larval development has occurred in constant conditions of temperature, humidity and darkness. For each temperature development took place at 30 per cent and 70 per cent relative humidity. A black square represents the time of pupation, to the nearest week, of one individual

at 25·0° C. were fully grown. There followed a period of diapause when little or no development occurred. Next came a second active period, during which the small larvæ moulted and reached the fully grown stage, while the larvæ already fully grown pupated, forming the first-year group of pupæ. This alignment of alternating active and diapause periods, in individuals developing at different temperatures, and therefore at different stages in their development, indicates an internal rhythm of development common to all.

The length of the cycle in this rhythmic development under constant conditions is about forty-one weeks, compared with the annual rhythm of development under outdoor fluctuating conditions. It is considered that the shorter interval is the basic one, and that, when diapause is completed, activity (involving both moulting and pupation) will proceed as soon as the temperature is above the threshold for development. This also furnishes an explanation for the lack of variation in the time of pupation under outdoor conditions (29 individuals varied by less than 4 days at the end of two years development) compared with that under constant conditions (Fig. 1).

Some of the laboratory experiments commenced in August, some in November and some in December. Relative humidity was controlled, and any diurnal or seasonal changes in carbon dioxide concentration were masked. The experiments were carried out in complete darkness except for short exposures of the insects to daylight or to tungsten illumination when they were being examined. Some experiments were started with the progeny of adults from laboratory cultures, others with the progeny of adults from flowers, but these differences did not materially influence the results. All eggs were incubated at 20·0° C., 70 per cent relative humidity, and the experiments set up with newly emerged larvæ.

At 20° C. simple crossings were made between individuals taking two years to develop. The F_1 progeny fell into two groups (one-year and two-year) in approximately the same proportion as in the original population.

A more detailed account is in the press[1].

G. M. Blake
Pest Infestation Laboratory
(Department of Scientific and Industrial Research),
London Road, Slough.
Nov. 19.

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A New Method for delaying Pupation in *Drosophila melanogaster*

Methods of delaying pupation in *D. melanogaster* are not only of interest in relation to the physiology of metamorphosis but also provide useful tools for developmental-genetical studies. Up to the present, the main method available has been that of Beadle, Tatum and Clancy[1]. They kept larvæ, aged less than 70 hr., on a low food-level provided by 1·5 per cent agar and 0·25 per cent brewer's yeast. According to Bodenstein[2] most of the larvæ starved in this way fail to survive, particularly, of course, those starved from early ages; moreover, the period for which pupation is delayed is highly variable, since in some cases larvæ pupate only one day late whereas in others the delay might be as much as five days.

A method has been found to delay pupation from six to seven days. The experiments were made with wild-type *Or.K.* stock. The eggs were laid over a 2-hr. period on agar medium and left for 20 hr., after which all the larvæ hatched during this period were removed. The remaining eggs were then raised on agar-molasses medium composed of 2 per cent agar, 17 per cent molasses and 1·5 per cent dry yeast. After 70 hr. from egg deposition (48 hr. after hatching), the larvæ were transferred to other vials containing the same food medium mixed with benzamide at concentrations of 2·0–6·0 per cent. In each vial, 12–15 larvæ were raised. Throughout the whole period of experiments, the temperature was kept at 25° C.

Nine days from egg-hatching, that is, five days after the control larvæ had pupated and one day after the flies had emerged from the pupæ, the test vials were examined. As shown in Table 1, at 2·0 per cent benzamide, about 88·8 per cent of the test larvæ have retained their larval characteristics, the remainder having become prepupal. The mortality-rate was insignificant.

Table 1. Effect of Benzamide on 48-hr.-old Larvæ of *D. melanogaster* (observed Nine Days after Hatching)

Conc. (per cent)	No. of test larvæ	Larvæ retarded		Pre-pupæ		Mortality-rate	
		No.	Per cent	No.	Per cent	No.	Per cent
2·0	54	48	88·8	5	9·2	1	2·0
4·0	69	66	95·6	—	—	3	4·4
6·0	69	67	97·1	—	—	2	2·9

At 4·0 and 6·0 per cent benzamide no pupation occurred, and nearly all the test larvæ remained in the food culture as mature third instar. These arrested larvæ were well able to withstand the experimental conditions, mortality-rate being small. When they were transferred to ordinary food, the percentage of recovery was very high. Pupation usually occurred 1–2 days after the transference. In other words, the whole period of delay was 6–7 days, 5 days with the treated food and 1–2 days with the ordinary one.

Table 2. Fate of Retarded Larvæ after Transference to Ordinary Food

Conc. of benzamide (per cent)	No. of transferred larvæ	Recovered larvæ	
		No.	Per cent
2·0	24	23	95·8
4·0	22	21	95·4
6·0	20	18	90·0

I am indebted to Prof. C. H. Waddington for his encouragement throughout the progress of the work.

A. Abd-el-Wahab*
Institute of Animal Genetics,
Edinburgh.
Nov. 22.

* Present address: Zoology Department, University of Cairo.

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Collagen in the Perilemma of Insect Nerve

Insect nerves are enclosed in a sheath, the perilemma, made up of concentric layers of anisotropic protein micelles and resembling the connective tissue of vertebrates[1]. There is evidence that each lamina consists of rows of glycoprotein fibrillæ, oriented at right angles in successive layers, the whole embedded in a matrix of neutral mucopolysaccharide[2].

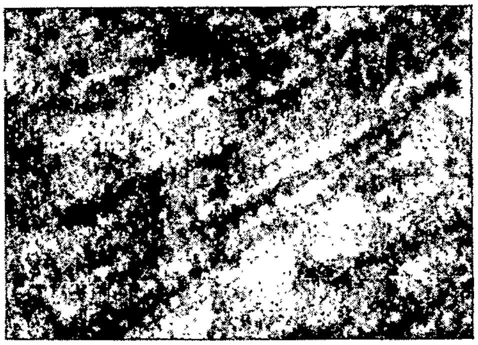

Fig. 1. Tangential section of perilemma of *Rhodnius* nerve. (× 30,000)

There has been some doubt as to whether the fibrous component of the perilemma is a collagen. Collagen is widely distributed in invertebrates[3]. By X-ray diffraction methods (wide-angle pattern), its presence has been established in crab nerve[4] and in subcuticular tissues of Crustacea and Mollusca[5]. By the same means Rudall[5] obtained definite evidence of its presence in small quantities in the ventral nerve cord of large mantids.

In the course of a re-investigation of the histology of the insect nervous system (V. B. W.), sections of the perilemma of the ganglia and large nerves of *Rhodnius prolixus* (Hemiptera) were prepared for the electron microscope (D. S. S.). Transverse sections reveal a series of rather dense fibrillar layers, with looser tissue between in which the fibres are differently oriented. Fig. 1 represents a somewhat thick tangential section showing the feltwork of banded fibres in one of the dense laminæ. Approximate measurements made on thinner sections gave a main periodicity of around 500–600 A. and a minimum diameter of about 150 A. In some fibres there are traces of secondary periodicity. These characters fall within the range of those of collagen in other groups of animals[3].

DAVID S. SMITH
V. B. WIGGLESWORTH

Department of Zoology,
University of Cambridge.
Nov. 4.

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Chromosome Number of the Potato Root Eelworm, *Heterodera rostochiensis* Wollenweber

Riley and Chapman[1] have recently reported that the diploid chromosome number of the female potato root eelworm is 18. During the course of a comparative study of the cytology of the genus *Heterodera*, I have found from a study of eggs undergoing meiosis that although this number appears to be usual in the potato root eelworm, eggs having 20 and 22 as the diploid number are not uncommon, while occasional eggs with 19, 23 and 24 may also occur. Material was fixed in Carnoy's fluid and stained with 1 per cent orcein in 45 per cent propionic acid using a squash technique. The distribution of chromosome number shown in Fig. 1 is based on 40 eggs from 32 females. In most cases where it has been possible to determine the chromosome number for more than one egg per female the determinations have agreed, but it is not certain whether this is always the case. The chromosomes are approximately 1μ long, so that counts may not be accurate in all cases; nevertheless it is clear that the number of chromosomes varies.

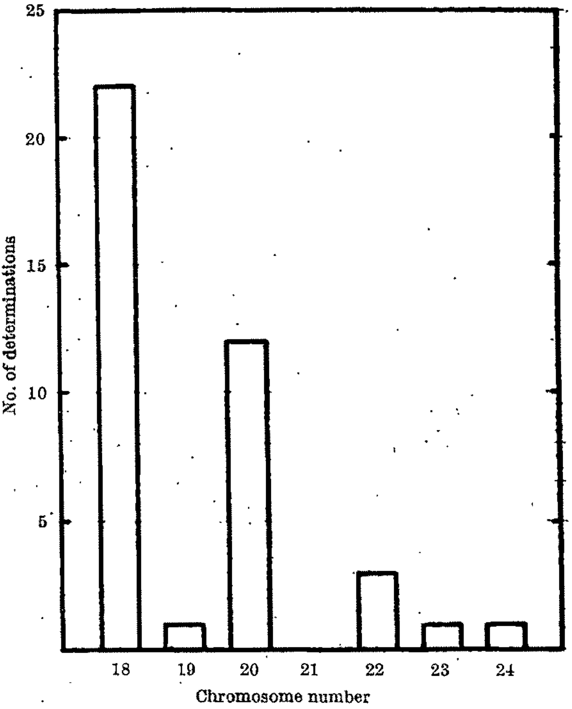

Fig. 1

One fertilized female was also found containing eggs with abnormally high chromosome numbers. 21 eggs were present, six undergoing meiotic division, and of these one had 47 chromosomes clearly arranged in a first anaphase figure, 23 in the upper plate and 24 in the lower. In none of the other five eggs were the chromosomes sufficiently clear to permit an accurate count, but in four of them the unreduced chromosome number was not less than 36, a number which falls outside the range shown in Fig. 1. The egg containing 47 chromosomes was apparently tetraploid; it is not possible, however, to say whether the whole of the parent female was tetraploid or only portions of the reproductive tract. Some years ago, Onions[2] reported from this laboratory the occurrence of four giant larvæ of potato root eelworm in one cyst (female), and suggested that they might be polyploid; their egg shells were also about twice the normal size. In the present case, the sizes of four fixed and stained eggs having abnormally high chromosome numbers fell within the range for comparable eggs of normal chromosome number.

The work is supported by a grant from the Agricultural Research Council, for which I wish to express my thanks.

J. COTTEN

Department of Zoology,
King's College,
University of Durham,
Newcastle upon Tyne.
Oct. 23.

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Singing Pattern of the Common Chaffinch, *Fringilla coelebs* Linn.

In a recent communication[1] describing the results of research carried out at Cambridge on song learning in *F. coelebs gengleri* it is stated that the natural song of this bird has a length of 2–2·5 sec., followed by a silent interval of 10–20 sec. Systematic records of the singing pattern of *F. coelebs* obtained here over a number of years suggest that Cambridge results quoted above may not be fully representative of the native chaffinch population of the British Isles.

The present communication describes the results obtained from detailed records of chaffinch song at Sidmouth covering three breeding seasons—1946, 1953 and 1954. Values of the 'song interval', defined by the time taken to utter the characteristic tri-phrase song once, have already been reported for the season of 1946[2]. The results presented here include new data on the rate of singing obtained in 1953 and 1954 based on a total of 9,435 records of individual birds belonging to the same local population as that used in 1946.

From the combined data, grouped mean values of total singing time, T_s, and total silent period T_q (both expressed in sec. per min.) have been derived for 10-day intervals during the breeding cycle. Additionally, 10-day mean values of the quantity, 100 (T_s/T_q), designated hereafter the 'song ratio', have been computed to provide a useful index of singing activity. Table 1 summarizes the results obtained during the most active period of breeding song for 55 until 125 days from the onset of singing.

Table 1. Seasonal March of Song Activity (*F. coelebs* Linn.)

Days from onset of singing	Song interval (sec.)	Song frequency (per min.)	T_s	T_q	Song ratio (per cent)
55	2·00	6·4	12·8	47·2	27
65	2·05	6·8	14·2	45·8	31
75	2·15	7·1	15·3	44·7	34
85	2·20	6·6	14·5	45·5	32
95	2·20	5·5	12·1	47·9	25
105	2·15	4·8	10·3	49·7	21
115	2·10	4·7	9·9	50·1	20
125	2·00	4·7	9·4	50·6	19

Both duration of song and rate of singing are seen to vary in response to the biological stimulus of the breeding cycle. The former exhibits a flat maximum at 85–95 days from onset of singing, while the latter passes through a more pronounced maximum phase at 75 days from onset. There is also a significant increase of the time spent by each bird in actual song (relative to the rest period) as the peak of the breeding cycle is approached, maxima of T_s, and 'song ratio', occurring at 75 days from commencement.

Turning now to the observed march of singing activity as reflected by the percentage values of the 'song ratio' entered in the last column of Table 1, it is seen that between the sixty-fifth and eighty-fifth days a consistently high level of activity is sustained, the maximum reaching almost 35 per cent at the seventy-fifth day.

It is of further interest to compare the mean values of the 'song ratio' for the whole period of 70 days with that computed from the Cambridge data already mentioned[1]. Table 2 shows clearly that the average song activity found at Sidmouth is about 10 ± 5 per cent greater than the corresponding level of activity for Cambridge.

Table 2. Comparative Song Data for Cambridge and Sidmouth

Locality	Mean song duration (sec.)	Mean rest period (sec.)	Mean song ratio (per cent)
Cambridge (eastern counties)	2·3	15·0	17 ± 4
Sidmouth (south-west England)	2·1	8·2	26 ± 5

Reference to the third column of Table 2 shows that the principal cause of this difference is the shortened rest-period observed at Sidmouth, with an average duration only about one-half of that reported for Cambridge.

These results suggest that significant differences in the level of breeding song activity may well exist between bird populations in different parts of the country, birds native to south-west England, for example, being consistently more energetic songsters than those resident in the eastern counties.

D. R. Barber

Lamacraft, Manor Road,
Sidmouth, Devon.
Nov. 8.

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Population Differentiation within Plant Species in Response to Soil Factors

The possible existence of populations within a single species adapted to different soil conditions has long been realized and they have been termed 'edaphic ecotypes'[1]. However, few cases of their occurrence have been described, and very few of these are in relation to soil conditions normally encountered[2], most being in relation to special soil conditions such as in soils of serpentine origin or contaminated by heavy metals[3,4]. This is surprising in view of the fact that a major difference between many closely related species is often that of soil preference.

In an effort to determine if such differentiation occurs within some ecologically wide-ranging species we have used two techniques; first, the effect on growth of contrasting natural soils and, secondly, the analysis of individual factors, which are probably acting in these soils, by a sand-culture technique, thus allowing a more critical approach[5].

The populations so far studied have been: *Festuca ovina* (*a*) from a chalk escarpment at Melcombe Bingham, Dorset, and (*b*) from an acid peat area on the slopes of Pen yr Oleu Wen, Caernarvonshire; *Agrostis tenuis* (*a*) from an acid peat area, slopes of Carnedd Llewelyn, Caernarvonshire, (*b*) from an acid peat area, slopes of Plynlymon, Cards., (*c*) from a moderately base-rich woodland, Ruislip, Middlesex, and (*d*) from a moderately base-rich pasture, Waxham, Norfolk.

When tested in both a Hampshire chalk downland soil and an acid upland peat under greenhouse conditions, yields (dry weight) were as shown in Tables 1 and 2.

These results show conclusively that reaction to the widely contrasting soils is markedly different in the two populations of *Festuca ovina* (soil × population interaction significant at 0·1 per cent level). In contrast to this, however, *Agrostis tenuis* populations show no difference in reaction to the two soils (soil × population interaction not significant).

Some of the populations have also been tested for response to a range of calcium-levels in sand culture.

Table 1. *Festuca ovina* (Total Dry Weight gm.)

Population	Chalk soil	Peat soil	Total
Melcombe	14·58	10·46	25·04
Pen yr Oleu Wen	13·97	15·37	29·34
Total	48·55	25·83	54·38

Sig. diff. at 5 per cent prob., 1·56.

Table 2. *Agrostis tenuis* (Total Dry Weight gm.)

Population	Chalk soil	Peat soil	Total
Carnedd Llewelyn	11·54	19·95	31·49
Plynlymon	11·07	16·13	27·20
Ruislip	11·54	16·23	27·77
Waxham	13·67	22·36	36·03
Total	47·82	74·67	122·49

Sig. diff. at 5 per cent prob., 4·12.

The results are shown graphically in Figs. 1 and 2. There is very good correlation of these results with those of the soil experiment. The calcium-level × population interaction in *F. ovina* is significant at the 5 per cent level and is not significant in *A. tenuis*. It is interesting to note, however, that although *A. tenuis* was not adversely affected by high calcium levels in sand culture, when grown in chalk soil the yield was markedly reduced, symptoms suggesting that an induced iron deficiency was responsible for this.

These experiments, together with preliminary results with further populations of *F. ovina*, clearly indicate the occurrence of edaphic ecotypes within the species *F. ovina*, but no such differentiation in *A. tenuis*.

Similar sand culture work with *Trifolium repens* has yielded evidence of differentiation within this species also. Using populations ranging from chalk downland to base-poor uplands, significant treatment × population interactions in response to both calcium and phosphate have been obtained. By varying the calcium-level of the nutrient solution, it was found that at low calcium (4–8 p.p.m. calcium) upland populations outyielded a chalk downland population, the latter suffering severe calcium deficiency symptoms while the former were quite healthy. At high calcium the chalk downland populations outyielded upland populations. By varying the phosphate level it was found that the chalk and upland popula tions had similar phosphate requirements, and that this was lower than the requirement of a commercia Kent wild white clover.

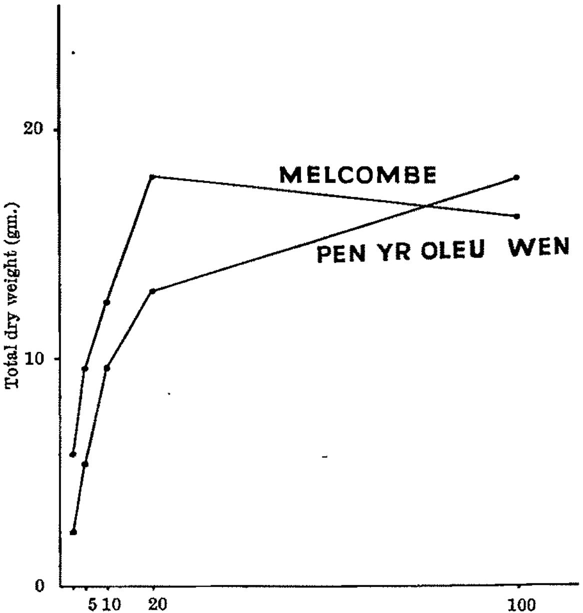

Fig. 1. *Festuca ovina*

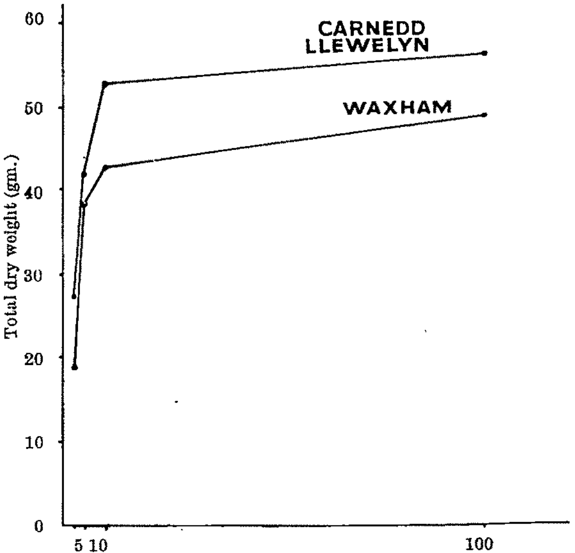

Fig. 2. *Agrostis tenuis*

These results suggest that differentiation in relation to common differences in soil type is more frequen than previously indicated.

This work is part of an investigation supported by a grant from the Agricultural Research Council, to which we are indebted.

A. D. Bradshaw
R. W. Snaydon
Department of Agricultural Botany,
University College of North Wales,
Bangor. Nov. 8.

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Occurrence of Two Characteristic Wealden Ferns in the Jabalpur Series

Plant fossils collected by us during the year 1957–58 from the Upper Gondwanas exposed nea Bansa, South Rewa Gondwana basin, and Sehora Satpura basin, include two well-known Wealden ferns, namely, *Weichselia* Stiehler and *Onychiopsi* Yokoyama. The collection from Bansa includes a few sterile fronds of *Weichselia* sp. (Figs. 1 and 2) The pinnules of these are slightly different from thos of *W. reticulata* in the nature of their reticulat venation. In our specimens the areolæ between th midrib and the margin are more elongate. Both th fertile and sterile fronds of *Onychiopsis* (Figs. 3 and 4 from Bansa resemble rather *O. capsulifera* described by Velenvosky[1]. The specimens of *Onychiopsis* from Sehora are all sterile and resemble rather *O. psilotoides* No *Weichselia* has so far been collected from Sehora

The age of these Upper Gondwana beds exposed near Bansa, Sehora and also at Jabalpur has long been

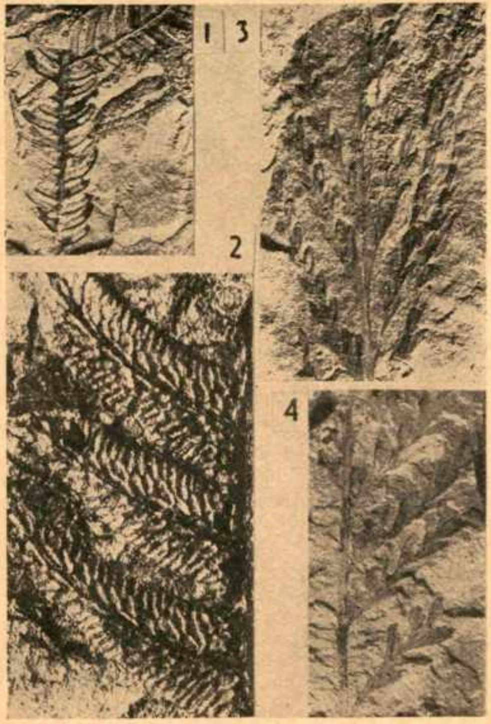

Fig. 1. *Weichselia* sp. (× 1). Fig. 2. Three pinnules of *Weichselia* (× 5). Figs. 3 and 4. *Onychiopsis* sp. (× 1). All the specimens are from Bansa, Madhya Pradesh

in dispute. Three views have been put forward: the first was expressed by Feistmantel[2], who considered them to be Middle Jurassic; the second is by Wadia[3], who regards these beds as Upper Jurassic; and the third is by Matley[4], according to which these are Lower Cretaceous.

On the evidence of the present findings, the age of the Jabalpur series cannot be fixed with absolute certainty. However, considering all the known records of *Weichselia* and *Onychiopsis*, which lie mostly in the Wealden, it is more apt to refer the Jabalpur exposed near Bansa and Sehora to the Lower Cretaceous.

M. N. Bose
Sukh Dev

Birbal Sahni Institute of Palæobotany,
Lucknow.

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Resistance of *Anopheles aquasalis* Curry to Dieldrin in Trinidad

Work at the Ross Institute with *Anopheles gambiae* revealed that dieldrin resistance is due to an allele of a single gene. When tested with papers impregnated with a mineral oil solution of this insecticide, the heterozygotes for this allele can withstand 0·4 per cent dieldrin for 1 hr. and the homozygotes for this resistant allele can withstand 4·0 per cent dieldrin for 1 hr.

It does not necessarily follow that the same applies to *Anopheles aquasalis* Curry, which is now known to be resistant to dieldrin in Trinidad. However, the same technique was applied using freshly blooded females taken from Shannon dawn traps located in the Barataria area of Trinidad.

On October 10, 1958, using World Health Organization 0·4 per cent dieldrin-impregnated papers, 354 mosquitoes were exposed in 14 World Health Organization kit tubes for 1 hr. and then held 24 hr. At the end of this period there were 339 survivors, which were re-exposed to 0·4 per cent papers for 1 hr. and held for a second 24-hr. period. There were 290 survivors, that is, 81·9 per cent, all of which appeared to be unaffected by the insecticide. 56 mosquitoes in two tubes were used as control, 48 of which survived the same treatment as the test mosquitoes except that the control papers were impregnated only with risella oil.

On October 13, 1958, the test was repeated with World Health Organization 4·0 per cent papers using 377 mosquitoes from the same source. There were 182 survivors, that is, 48·3 per cent. 56 mosquitoes were used as control, of which there were 52 survivors.

It is possible, therefore, from these results that just over 40 per cent of the population tested were homozygous for resistance to dieldrin.

T. A. Omardeen

Malaria Division,
P.O. Box 556,
Port of Spain,
Trinidad.
Nov. 17.

METEOROLOGY

Drift of Toxic Chemicals released from a Low-flying Aircraft

When toxic chemicals, such as herbicides or insecticides, are applied under field conditions, there is a risk that damaging concentrations will occur at distances downwind from the source, and that harm will be done to crops, or to livestock and human beings. Of particular interest is the drift of chemicals released from a low-flying aircraft.

An Auster *J 5G*, a small high-wing monoplane, was fitted with a boom-and-nozzle system which produced a spray with a volume median diameter of approximately 200μ, using dyed Shell 'Diesoline', a liquid for which evaporation is slow at these droplet sizes. The aircraft was flown 10 ft. above the ground in open rolling grassland, and several long runs were made at right angles to the direction of the wind. Relevant meteorological records were kept. Deposits upon the ground were estimated colorimetrically after extraction of the dye from large filter papers, and airborne concentrations, in terms of the amounts passing a vertical area at right angles to the wind, were sampled at a height of 3 ft. by means of cascade impactors[1].

For two such experiments the wind speeds were about 8 ft./sec., and the turbulence factor[2] (F) was -3×10^{-3}. The ground deposits are recorded in Fig. 1, using log–log paper, while Fig. 2 gives comparable results for the airborne concentrations; for ease of presentation the results have been calculated for an emission of 100 c.c. per yard of flight. Despite the scatter of the points, and some shortcomings of technique, particularly in the use of cascade impactors to sample such relatively coarse sprays, reasonably reproducible results were obtained.

The cumulative effect of successive swathes in an area is of interest. With a small aircraft a swathe-width of 15 yd. would be representative of, for

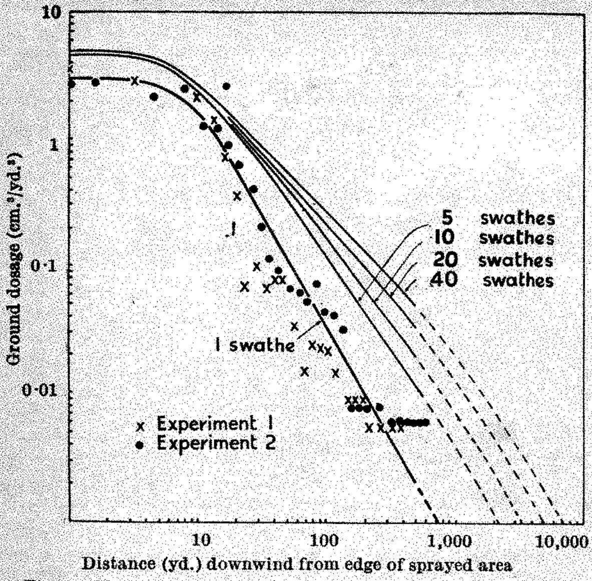

Fig. 1. The variation in ground dosage with distance downwind

example, applications of herbicides in crops, and, using this swathe width and the basic graphs of Figs. 1 and 2, the build-up of dosages has been calculated for various distances downwind from the downwind edge of areas subjected to 5, 10, 20, and 40 successive swathes. An increase in the number of swathes from 1 to 5 increases the ground deposit and the airborne concentration at the downwind edge of the target area by about twice, but a further increase in the number of swathes to 40 results in only a slight further increase. At 100 yd. downwind the swathes are still not additive, the hazard from 40 swathes being only 8–10 times that of one; at 1,000 yd. the hazard from 40 swathes is about 30 times that of one swathe, while it may be inferred that at 10,000 yd. the swathes would be nearly additive, in any event for an involatile liquid.

The results indicate the hazards to be expected for distances of up to a mile or so downwind from a sprayed area. It would be more generally useful to extend the sampling for a few miles downwind, and it is hoped that this will be possible. Variations in droplet size and meteorological conditions are likely to have an effect upon dosage distributions, and their influence is being investigated.

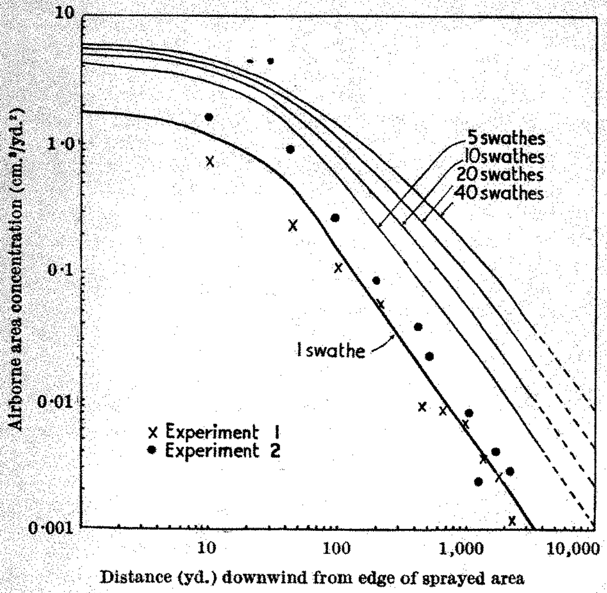

Fig. 2. The variation in airborne concentration with distance downwind

D. Yeo
N. B. Akesson*
H. H. Coutts

Colonial Pesticides Research Unit,
Arusha, Tanganyika.

* On leave from the University of California, Fulbright Assignment.

[1] May, K. R., *J. Sci. Instr.*, **22**, 187 (1945).

[2] Yeo, D., and Thompson, B. W., *Nature*, **172**, 168 (1953).

World Variation in Annual Rainfall

The following analysis is based on the figures given by Conrad[1] which cover 358 stations in the belt 60° N.–60° S. The aim of the work was to test the validity of the statement frequently quoted that rainfall variation is much greater in the tropics than in the temperate regions. The broad result of the investigation shows that this is not strictly true.

Conrad has used the mean deviation as the variance factor, v_a, relating this to p, the mean annual precipitation, so that $v_a/p = v_r$. First, the stations were zoned within 20° belts and the differences of the mean of v_r examined.

Table 1. Values of Probability versus Difference of Means of v

	60°–40° N.	40°–20° N.	20°–0° N.	0°–20° S.	20°–40° S.	40°–60° S.
60°–40° N.	—	< 0·001	0·06	< 0·02	< 0·001	>0·2
40°–20° N.	< 0·001	—	< 0·001	>0·2	0·13	0·09
20°–0° N.	0·06	< 0·001	—	0·10	< 0·001	>0·2
0°–20° S.	< 0·02	>0·2	0·10	—	>0·2	0·16
20°–40° S.	< 0·001	0·13	< 0·001	>0·2	—	< 0·02
40°–60° S.	>0·2	0·09	>0·2	0·16	< 0·02	—

Table 1 shows the probability values obtained, and makes clear the fact that there is no significant difference between areas symmetrically placed north and south of the equator. It was therefore permissible to add the respective zones.

Table 2

	Mean of v_r	Variance of v_r	Mean p (mm.)	v_r calculated	n
60°–40° N. and S.	15·5	22·0	799	17·0	125
40°–20°	22·9	110·9	958	16·5	154
20°–0°	19·3	128·8	1,936	15·0	79

From Table 2 it can be shown that the mean of the 40°–20° belt is significantly higher than the other belts, and that 20°–0° is higher than 60°–40°. Conrad has derived an equation connecting v_r and p, and from this v_r was calculated. Columns 1 and 4 in Table 2 stress the fact that it is within the sub-tropics that annual rainfall variation is the greatest.

It was, unfortunately, not possible to test differences of v_r within narrow annual rainfall groups, as the number of stations was too few; but a detailed analysis will soon be made using European and African stations.

J. F. Griffiths

East African Meteorological Department,
Nairobi, Kenya.

Nov. 8.

[1] *Monthly Weather Rev.*, **69**, 5 (1941).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 12

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. F. Waismann: "Logic and Reality".

University of London (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. G. Schwarzenbach (Zürich): "Solution Chemistry of Metal Cations".* (Special University Lecture in Chemistry. Further lecture on January 13.)

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Sir John Hunt, C.B.E., D.S.O.: "Climbing in the Caucasus Mountains of the U.S.S.R.".

Tuesday, January 13

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Kalmus: "Genetical and Cultural Transmission in Animals and Man".*

Institution of British Agricultural Engineers (at 6 Buckingham Gate, London, S.W.1), at 2.15 p.m.—Mr. A. Senkowski: "Ground Adhesion Problems of Wheeled Agricultural Tractors".

Institution of Naval Architects (at the Institute of Marine Engineers, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. S. J. Jones and Mr. J. K. W. MacVicar: "Development of Air Conditioning in Ships".

Institution of the Rubber Industry, London Section (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. S. E. Bolam: "Compounding Nitrate Rubber for Specific Properties". 7 p.m.—Dr. G. Bielstein: "Some Aspects of High Temperature Vulcanization".

Society of Chemical Industry, Chemical Engineering Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. E. W. Greensmith: "An Organization for Inspection".

Institution of Electrical Engineers, Education Discussion Circle (joint meeting with the London Graduate and Student Section, at Savoy Place, London, W.C.2), at 6.30 p.m.—Discussion on "Education and Training from the Student's Point of View".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Lecture on "Stress Corrosion".

Wednesday, January 14

Society for Applied Bacteriology (in the Barnes Lecture Theatre, Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 10 a.m.—Business Meeting. 10.15 a.m.—Scientific Papers. 2 p.m.—(joint meeting with the Microbiology Group of the Society of Chemical Industry)—Symposium on "Differential Media".

Physical Society, Colour Group (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 3 p.m.—Mr. H. Cole: "The Chemistry of Coloured Glasses"; Dr. R. A. Weale: "Third Thoughts on Cone-Monochromatism".

Institute of Physics, London and Home Counties Branch (in the Lecture Theatre of the Royal Institution, 21 Albemarle Street, London, W.1), at 5.30 p.m.—Sir George Thomson, F.R.S.: "Controlled Thermonuclear Reactions".

Society of Instrument Technology, Data Processing Section (at Manson House, Portland Place, London, W.1), at 6 p.m.—Symposium on "Storage Media".

Thursday, January 15

Physical Society, Low Temperature Group (in the Lecture Theatre of the Royal School of Mines, Prince Consort Road, South Kensington, London, S.W.7), at 4 p.m.—Thirteenth Annual General Meeting.

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. T. P. Hoar: "The Production of Copper and Sulphur by the Electro-decomposition of Cuprous Sulphide"; Dr. E. T. Turkdogan: "Equilibrium Measurements Between Carbon-Saturated Mn-Fe-Si Melts and CaO-Al_2O_3-MnO-SiO_2 Slags".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. B. J. Birch: "Rational Solutions of Equations".

University College, Faculty of Laws (in the Eugenics Theatre, Gower Street, London, W.C.1), at 5 p.m.—Prof. D. Lloyd: "Liability for Radiation Injuries".*

Institution of Electrical Engineers, Utilization Section (in conjunction with the British Nuclear Energy Conference, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. N. J. Mackay and Mr. E. Hardwick: "Electrical Installation at Calder Hall Nuclear Power Station".

Royal Anthropological Institute (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. Trefor M. Owen: "The Bidding and Related Marriage Customs in Nineteenth-Century Wales".

Institution of Mechanical Engineers, Steam Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Boiler Feed Water".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. G. E. Bessey: "Aerated Concrete".

Institute of Metals (at 17 Belgrave Square, London, W.1), at 6.30 p.m.—Dr. C. E. Birchenall (Princeton University): "The Oxidation of Metals at High Temperatures".

Wool Education Society (at the Royal Institution, Albemarle Street, London, W.1), at 7 p.m.—Mr. A. N. Davidson: "Shrink-Free Wools—a Scientific Achievement".

Chemical Society (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. J. Baddiley: "Nucleotides and Bacterial Cell Wall Components" (Tilden Lecture).

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. P. E. C. Manson-Bahr: "East African Kala-azar, with special reference to the Pathology, Prophylaxis and Treatment".

Friday, January 16

British Mycological Society (in the Large Physics Theatre, Birkbeck College, Malet Street, London, W.C.1), at 11 a.m.—Symposium on "Some Aspects of Diseases of Vegetables".

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. W. J. Charnley: "Blind Landing Problems".

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. J. K. Royle: "Inherent Non-Linear Effects in Hydraulic Control Systems with Inertia Loading"; Dr. D. E. Turnbull: "Response of a Loaded Hydraulic Servomechanism".

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—Dr. Robert M. Page: "Frontiers of Space Research".

Society of Chemical Industry, Fine Chemicals Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. E. E. Boake: "Development of Aromatic and Perfumery Chemicals".

Saturday, January 17

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. D. L. Snellgrove: "Buddhist Shrines of Nepal".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Electrical Engineering, to teach power and distribution up to Higher National Certificate standard—The Principal, Dudley and Staffordshire Technical College, Dudley (January 15).

Senior Library Assistant (graduate with suitable library experience) in the Science and Social Science Section of the University Library—The Librarian, The University, Birmingham 15 (January 16).

Assistant Experimental Officer (with a degree in science or horticulture) in the Physiology Section—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (January 17).

Experimental Officers, Grade 1 (with a degree or diploma in mechanical, electromechanical or aeronautical engineering fields), at the Weapons Research Establishment, Australian Defence Scientific Service, near Adelaide, South Australia, for duties associated with a group responsible for the design, development and launching of special purpose rocket propelled vehicles—The Senior Representative (A.V.12/6), Department of Supply, Australia House, Strand, London, W.C.2 (January 19).

Senior Lecturer (honours graduate) in Glass Technology at St. Helen's Technical College—The Director of Education, Education Office, St. Helen's, Lancs (January 20).

Assistant Technical Editor (with at least a pass degree in science, technology or arts) in the Ministry of Power, Sheffield, for work on reports and papers concerning safety in mines research—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.266/8A (January 24).

Physicist, Senior Scientific Officer (with a good honours degree in physics, and preferably general physical experience and a knowledge of radiochemical equipment), in the Scientific Branch, L.C.C. County Hall, for research work on properties of materials and in the field of health physics—The Medical Officer of Health (PH/D.1/A), County Hall, London, S.E.1 (January 24).

Lecturer, and an Assistant, Grade B, in the Department of Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (January 26).

Soil Analyst (with a degree in chemistry, agricultural chemistry or an equivalent professional qualification from a recognized university or other institution) in the Department of Agriculture, University College of Ghana, to assist in the research programme of the Division of Soil Science—The Assistant Registrar (London), University College of Ghana, 29 Tavistock Square, London, W.C.1 (January 26).

Assistant Lecturer in Applied Mathematics—The Secretary, The University, Belfast (January 30).

Chemical Engineer or Fuel Technologist (with a university degree in science, chemical engineering or fuel technology (with chemistry as a major subject) or equivalent qualifications) in the Coal Research Section, C.S.I.R.O., North Ryde, New South Wales, Australia, to take part in pilot scale investigations on the carbonization of coal in connexion with the Section's research programme into the properties of Australian coals and the improvement of the quality of metallurgical coke made from these coals—Chief Scientific Liaison Officer, Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 480/250 (January 31).

Lecturer in Biochemistry—The Secretary of University Court, The University, Glasgow (January 31).

Lecturer (with a degree in electrical engineering, and preferably experience in one or more of the fields of light current engineering) in Electrical Engineering at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

Lecturer (with an honours degree in civil engineering and preferably research or teaching experience in materials and structures) in **Civil Engineering** at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

Lecturers (2) (preferably, but not necessarily, experience of research work in experimental or theoretical nuclear physics) **in the Department of Physics**—The Registrar, The University, Liverpool (January 31).

Plant Nutrition Officer (with a first-class honours degree in agricultural science or science, or higher academic qualifications, and research experience) at the Western Australian Regional Laboratory, Division of Plant Industry, C.S.I.R.O., Perth, to participate in a programme of pasture investigations in Western Australia—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 135/46 (January 31).

Professor of Inorganic Chemistry—The Registrar, Indian Association for the Cultivation of Science, Jadavpur, Calcutta 32, India (January 31).

Lecturer/Senior Lecturer (with postgraduate experience in veterinary anatomy) **in Veterinary Anatomy** at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 2).

Research Fellow and **Senior Research Fellows** (2) **in the Department of Experimental Pathology**; **Research Fellows** (2) **in the Department of Medical Chemistry**; and a **Fellow, Research Fellow**, and **Senior Research Fellow in the Department of Physiology**, John Curtin School of Medical Research, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or the Registrar, Australian National University, Box 4, G.P.O., Canberra, A.C.T. (February 6).

Turner and Newall Research Fellows in Engineering, Inorganic Chemistry, Physics and allied subjects—The Registrar, The University, Manchester 13 (February 14).

Senior Lecturer (suitably qualified and experienced graduate in chemistry or agricultural chemistry) **in the Department of Chemistry and Soil Science**, Imperial College of Tropical Agriculture, Trinidad, West Indies, to teach plant and animal biochemistry to students reading for the B.Sc.(Agric.) degree—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (February 24).

Assistant Lecturer in Applied Mathematics (Geophysical)—The Secretary, The Queen's University, Belfast (February 25).

Chair of Botany in the University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 28).

Lecturer in Tropical Hygiene—The Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (February 28).

Imperial Chemical Industries Research Fellows (2) **in Chemistry, Physics, Physical Chemistry, Biochemistry, Chemotherapy, Pharmacology, Pharmacy, Colloid Science, Metallurgy, Engineering, Geology** or **Agricultural Science**—The Registrar, University of Wales, University Registry, Cathays Park, Cardiff (March 7).

Chair of Mathematical Statistics in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 9).

Lecturers or **Assistant Lecturers** (with experience in at least one of the following fields—generation, transmission and/or distribution of electrical power, measurements, electrical machinery) **in Electrical Engineering**—The Secretary, The Queen's University, Belfast (March 20).

Assistant (preferably graduate in chemistry, biochemistry, or physiology) **in the Department of Pathology**, to help in research in connexion with the investigation of steroids—The Clerk to the Governors, St. Bartholomew's Hospital, London, E.C.1, marking envelope "Research".

Chemist or **Biochemist** (with postgraduate experience and preferably a knowledge of immunochemistry and carbohydrate chemistry), for a wide range of biochemical research concerned with diseases of sheep—The Secretary, Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh 9.

Fellow in the Department of Chemistry, for fundamental research on electron resonance spectroscopy—The Registrar, The University, Birmingham 15.

Laboratory Assistant (preferably with a knowledge of chemistry and experience of handling scientific apparatus), for duties in the Chemistry and Biology Laboratories—The Principal, Coventry Technical College, The Butts, Coventry.

Senior Lecturer (with a wide general knowledge of microbiology and industrial experience, preferably in the food industry) **in Applied Microbiology**—The Secretary/Treasurer, Royal College of Science and Technology, Glasgow, C.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 43: The Polishing of Roadstone in Relation to the Resistance to Skidding of Bituminous Road Surfacings. By D. J. Maclean and F. A. Shergold. Pp. iv+30+4 plates. (London: H.M. Stationery Office, 1958.) 3*s*. net. [311

Admiralty and Ministry of Supply. Inter-Service Metallurgical Research Council. Corrosion of Metals by Vapours from Organic Materials: a Survey. By Vera E. Rance and H. G. Cole. Pp. iv+25. (London: H.M. Stationery Office, 1958.) 2*s*. net. [311

Classified Radiographs for Defects in Aluminium Fusion Welds, with Notes on their Origin and Prevention. Prepared by P. T. Houldcroft, J. G. Young and A. A. Smith. Pp. iii+51. (London: British Welding Research Association, 1958.) 10*s*. [311

Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series 2, Volume 22, No. 3: The Lobster Fishery of Wales. By A. C. Simpson. Pp. ii+33+4 plates. (London: H. M. Stationery Office, 1958.) 9*s*. net. [311

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 3, No. 21: *Levicaulis arranensis*, gen. et sp. nov., a Lycopsid Axis from the Lower Carboniferous of Scotland. By Dr. Charles B. Beck. Pp. 445–457+2 plates. (Edinburgh: Royal Society of Edinburgh, 1958.) 6*s*. [311

Department of Scientific and Industrial Research. Food Investigation 1957: The Report of the Food Investigation Board with the Reports of the Superintendents of the Torry Research Station, the Low Temperature Research Station, and the Ditton Laboratory. Pp. vi+81. (London: H.M. Stationery Office, 1958.) 5*s*. net. [511

British Institution of Radio Engineers. Library Services and Technical Information for the Radio and Electronics Engineer. Pp. 72. (London: British Institution of Radio Engineers, 1958.) 2*s*. 6*d*. [511

National Central Library. 42nd Annual Report of the Executive Committee for the year ending 28 February, 1958. Pp. 18. (London: National Central Library, 1958.) [611

Scottish Marine Biological Association. Annual Report 1957–58. Pp. 34. (Millport, Isle of Cumbrae: Scottish Marine Biological Association, 1958.) 4*s*. [611

National Physical Laboratory. Mathematical Tables, Vol. 2: Tables of Everett Interpolation Coefficients. By Dr. L. Fox. Pp. 61. (London: H.M. Stationery Office, 1958.) 10*s*. 6*d*. net. [611

Other Countries

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Technique No. 53: Le Débit des Bois a la Scie a Ruban. 3: Étude du Sciage de *Staudtia stipitata*, *Guaera cedrata*, *Cynometra alexandrii* et *Pycnanthus angolensis*. Par R. C. Antoine et J. C. Berben. Pp. 75. 70 Belgian francs. Série Technique No. 54: Méthodes d'Analyses Minérales. Par Dr. A. Gils et N. Moumm. Pp. 31. 20 Belgian francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1958.) [311

East African High Commission. East African Trypanosomiasis Research Organization Report, July 1956—December 1957. Pp. ii+81. (Nairobi: Government Printer, 1958.) Sh. 7/50. [311

Bulletin of the American Museum of Natural History. Vol. 116, Article 1: The Spider Family Dictynidae in America North of Mexico. By Prof. Ralph V. Chamberlin and Willis J. Gertsch. Pp. 1–152+plates 1–47. (New York: American Museum of Natural History, 1958.) 3.50 dollars. [311

The Carlsberg Foundation's Oceanographical Expedition Round the World 1928–30, and previous "Dana" Expeditions. "Dana"—Report No. 47: *Omosudis* Günther, Bathypelagic Genus of Fish. By Vilh. Ege. Pp. 19. (Copenhagen: Andr. Fred. Høst & Søn, 1958.) 4 Danish Kr. [311

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Bulletin Climatologique Annuel du Congo Belge et du Ruanda–Urundi, Année 1957. (Bureau Climatologique Communication No. 16.) Pp. 177. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1958.) [311

The Weizmann Institute of Science, Report, 1956–1957. Pp. 190. (Rehovoth, Israel: The Weizmann Institute of Science, 1958.) [511

Insect Toxicologists' Information Service. Bulletin, No. 1. Pp. 106. (Utrecht: Insect Toxicologists' Information Service, Vondellaan, 6, 1958.) [611

Bulletins de la Société Royal de Zoologie d'Anvers. No. 6: Schildkröten-Pflege in Offentlichen Schau-Aquarien nach Biologischen Gesichtspunkten. Von Dr. Agatha Gijzen und Dr. Heinz Wermuth. Pp. 65+52 plates. No. 7: Quelques Observations sur le Coeur de l'Okapi et sur la Circulation Coronarienne. Par Georges Candaele et A. Ghys. Pp. 4+8 figures. No. 8: Notice sur la Reproduction de l'Okapi *Okapia Johnstoni* (Sclater) au Jardin Zoologique d'Anvers. By Dr. Agatha Gijzen. Pp. 62+20 plates. (Anvers: Société Royale de Zoologie d'Anvers, 1958.) [1011

Aviation Psychology in Western-Europe and a Report on Studies of Pilot Proficiency Measurement. Papers Collected by J. B. Parry and S. D. Fokkema, with the collaboration of Ch. W. Bray, J. Benoit, A. A. Burrows, F. J. Miret y Alsina, E. Riis, K. Steininger, F. Strubbe, J. Termøhlen, J. Ungricht and M. Wächter. Pp. 64. (Publication No. 1 of the Western-European Association for Aviation Psychology.) (Amsterdam: Swets and Zeitlinger, 1958.) 15*s*. [1011

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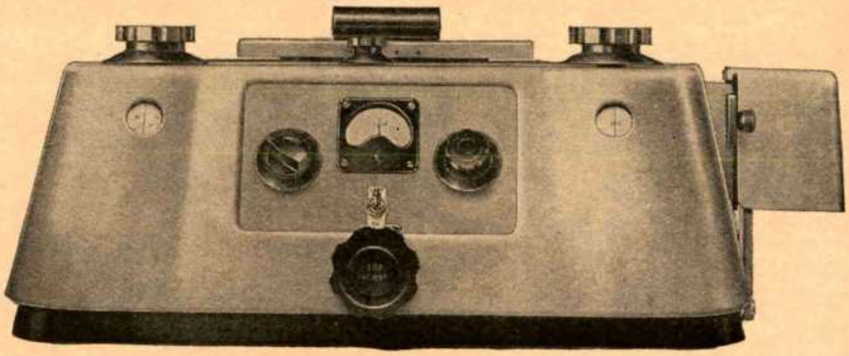

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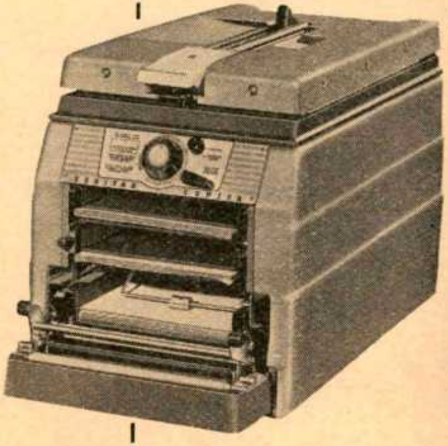

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AVAILABILITY OF SCIENTIFIC INFORMATION

IN January 1958, important statements regarding scientific publications in the United States, abstracting and the retrieving of scientific information were made to a Sub-Committee of the Congress Committee on Government Operations by such leading scientists as Dr. L. V. Berkner, president of the International Council of Scientific Unions, Dr. W. R. Brode, science adviser to the Secretary of State and president of the American Association for the Advancement of Science, Dr. D. J. Hughes, of the Brookhaven National Laboratory, Dr. H. T. Cox, director of the American Institute of Biologica Sciences, and Dr. Warren Weaver, of the Rockefeller Foundation and the National Science Foundation. Dr. Berkner suggested that absence of knowledge of work done elsewhere was probably the greatest cause of inefficiency in research, but he stressed the value of personal contact between scientists. He went on to recommend that the National Science Foundation should give immediate support to scientific periodicals and specialized publications, to permit and encourage prompt and full-scale publication in English of scientific literature and provide for its abstracting. He also recommended provision for encouraging and financing publication of U.S. Government research papers in recognized scientific periodicals and discouraging unnecessary use of Government research reports. International activities in the publication of scientific symposia and international efforts to improve the publication of abstract periodicals should also be supported, and the translation of scientific papers into English, the unification of translation by different agencies and prompt publication in periodicals regularly acquired by libraries should be subsidized.

With the immediate initiation of substantial and continuing research on subject classification, indexing and procedures for retrieving, designed to provide the scientists of the United States and other Western countries with full access to the scientific literature of the world, Dr. Berkner thought such a programme would repay its cost many-fold. He reiterated his belief that national security is based ultimately on an adequate supply of sound and effective weapons (and men well trained in their tactical use) from a virile industry ; on the recognition and public debate of weaknesses so that they can be corrected ; on a free and unfettered science and technology ; on a free and imaginative industry with full access to all knowledge ; on allies and friends, with whom scientists can deal freely and with a sense of full trust ; and on a society built on the foundations of mutual confidence upon which free enterprise depends. Dr. Berkner, it will be noted, recognizes the need for further sustained research into methods of retrieving information in the widest sense, and in this he was strongly supported by Dr. Hughes, who made this one of his main recommendations.

Dr. Cox, who, like Dr. Hughes, also urged the need to increase the American national effort in fundamental research, suggested it might well be doubled, to a figure of 800 million dollars (including private funds) ; he referred also to the need for investigating new methods for the rapid publication of scientific papers, as well as for the more efficient and cheaper printing of scientific periodicals, but he was concerned as to the danger of excessive centralization and did not view with favour gigantic national centres. In this he was supported by Dr. Weaver, and there was general agreement in these statements that the policy and control of such scientific projects must be in the hands of scientists themselves. Dr. Brode, who stressed particularly the magnitude of the present problem of retrieving information, strongly supported Dr. Berkner's proposal that funds should be available to the National Science Foundation to support studies in this field, but he was hopeful that the President's Advisory Committee on Science might help to solve some of the problems.

Dr. Weaver urged particularly the importance of a careful approach and considered order of priorities, suggesting that the problem would be clarified by the International Conference on Scientific Information which was to meet at Washington in November. We need, he said, to clarify the actual and proper purposes of publication, if only because the recorded word, at best, is a cold substitute for direct communication between scientists, and he stressed the value of removing hindrances to travel. Moreover, it was not simply a matter of communication between scientists themselves, but also of communication between scientists and the public. Dr. Weaver concluded by outlining a programme of public relations with three specific points, which embraced provision through the National Science Foundation of special fellowships for training young men and women in writing, in journalism and in the techniques of mass communication in science so that they could act as a communication link between science and the public ; the provision of funds to assist the American Association for the Advancement of Science to pursue its own plans in this field ; and requiring the major Government agencies concerned with fundamental research to provide intelligible and candid reports of their activities to the public. He reiterated the importance of giving Dr. J. R. Killian, special assistant for science and technology to President Eisenhower, full support, and of using the National Science Foundation and existing agencies to the full. In particular, he thought the Division of Information of the National Science Foundation, with adequate staff and support, would be ideally placed to deal with the information problem.

The Congress Committee was primarily concerned with the availability of information from Federal Departments and Agencies, although, as has been seen, no narrow view was taken of the information problem, and the use of the departmental research report was firmly discouraged by those who gave evidence before the Committee. The scope of the International Conference on Scientific Information at Washington (see p. 147 of this issue) was similar for, although its discussions were nominally concerned with problems of storing and retrieving information, panels examined the literature and reference needs of scientists, the effectiveness of abstracting and indexing services and also of monographs, compendia and specialized centres. Moreover, in his opening address, Sir Lindor Brown was no less searching and forthright than Dr. Weaver in the questions he raised about the purpose of publication, and the need for discipline and critical thought.

Many of the points emphasized before the Congress Committee recurred in the discussions at Washington, notably in those of the panel concerned with the responsibilities of governments, scientific societies, universities and industry for improved information services and research. The panel did not favour the establishment at present of an international scientific information centre, but rather the co-ordination of national services, for example, through national library services. The trend should be for more national centres and more international co-ordination.

The plan, approved on December 7 by President Eisenhower, for improving the availability of scientific and technical information in the United States is entirely in line with the trend of opinion at the Conference and with the views expressed to the Congress Committee last January. It is based on the findings of a report of the President's Science Advisory Committee, of which Dr. J. R. Killian, special assistant to the President for science and technology, is chairman, and Dr. L. V. Berkner is a member. The President's action reinforces the provision of the National Defence Education Act, 1958, which called for the establishment of a Science Information Service in the National Science Foundation to "provide, or arrange for the provision of, indexing, abstracting, translation, and other services leading to a more effective dissemination of scientific information, and undertake programmes to develop new or improved methods, including mechanized systems for making scientific information available". The President has now directed the National Science Foundation to take the lead in co-ordinating scientific information activities within the Federal Government of the United States and has asked all Federal agencies with programmes involving scientific information to co-operate with the National Science Foundation in improving the Government's efforts in this area.

The International Conference alone demonstrated the large extent to which scientific information services present problems common to all nations, even if solutions to particular problems may vary from country to country. This report of the President's Science Advisory Committee is thus of great interest to Britain, and apart from its bearing on the organization of a national library service for science and technology now belatedly under consideration, its clear presentation of the magnitude c the problem and its gravity may well help to convinc those in authority that the projects under consideration in Britain should receive more urgent an generous support than the Advisory Council fo Scientific Policy has yet been able to command The consequences of delay can no longer be ignored and the extent to which responsibility falls on th Government is clearly indicated.

Dr. Killian remarks that there are some 55,00 journals appearing annually, containing abou 1,200,000 articles of significance for some branch o research. In these fields, more than 60,000 different books are published annually, and abou 100,000 research reports remain outside the norma channels of publication and cataloguing. This vas body of scientific information, much of it i languages, such as Russian and Japanese, unknow to most English-speaking scientists, contains th technical data needed by scientists to do their work The rate of increase is indicated by the doublin every twenty years during the past century of th collections of science and technology periodicals i the Library of Congress. These now contain a millio and a half volumes, and about 15,000 are receive annually, with 1,200–1,300 new periodicals appearin each year. By 1979, it is expected that the worl output will reach 100,000 periodicals.

At present a mounting flood of scientific dat threatens to swamp even the most zealous researc investigator; yet our very progress in scienc depends upon the free flow of scientific informatio After reviewing what is already being done in th United States—where the fourteen major scientifi abstracting services are estimated to cover, with thei half-million abstracts, only about 55 per cent of wha is needed for reasonable cover—and stressing a recen trend in the establishment of data centres, th report firmly rejects the proposal to establish single and highly centralized scientific informatio agency, financed wholly or partly by the Federa Government, on the lines of the Soviet All-Unio Institute of Scientific Information.

The President's Committee does not believe tha the needs of the United States, where the researc effort is organized and administered on very differen lines from that of Soviet Russia, would be me effectively in this way. A long-term solution of th problem requires fundamental research into th problem itself and widespread application of mechanical methods and techniques. The Committe considers that the needs of the United States woul be better met by establishing a science informatio service of the co-ordinating type, which woul strengthen and improve the present system b taking full advantage of existing organizations an the special skill of persons with long experience i this field. Such a service, in the best America tradition of private enterprise and Governmen working together voluntarily for the national goo would have two important functions. First, b effective co-ordination of public agencies and privat organizations, it would improve existing facilities and techniques, so as to afford immediate relief to the most urgent short-term problems. Secondly, it would encourage and support the fundamental long-term programme of research and development, with the view of applying modern scientific knowledge to the whole problem, both by the use of mechanical techniques and the discovery of new methods.

Under the first category, the service would assist financially, where necessary, the publication of periodicals and monographs, encouraging also both publishers and scientific societies to experiment with new methods of publication. It would also sponsor and, if needed, support the immediate preparation of world lists of both primary and secondary scientific research publications, classified by subject and indexed, as well as sponsor a list of scientific and technical periodicals and provide a clearing house of information on abstracting and indexing services throughout the whole area of foreign scientific information, expanding the translation of Russian periodicals and initiating additional translation programmes in Japanese and other languages as required.

The service would give special attention to Government scientific reports, expanding the existing system of announcement to include all significant unclassified reports and improving facilities for making copies of these reports available on request. It would also seek to expand and improve throughout the world inter-library exchange agreements, photocopying processes, and other means of bringing to the scientist copies of items unattainable through normal channels. With sufficient funds and support, all this could be attempted at once; but in addition, under the second category, the service would support a continuing programme of research and development through grants and contracts, looking to the widespread application of mechanical techniques to such problems of storage, retrieving, indexing, translating and abstracting.

As already indicated, the Science Advisory Committee does not consider that a new agency is required. The National Science Foundation has specific responsibilities in this field, and a pilot programme has already supplied useful experience and special competence. The Science Information Service could easily be established within the Foundation by extending the Foundation's present programme, and this is the Committee's recommendation and the purpose of the President's action.

It will be apparent from this summary that what is now contemplated in the United States goes far beyond the present activities and responsibilities of the Department of Scientific and Industrial Research in Great Britain. A comparable activity in Britain is that of the Association of Special Libraries and Information Bureaux, which is now turning its attention to the long-term problems of research and development. Further, the Nuffield Foundation has for some time been seeking to foster the examination of new techniques of publication; and Anglo-American co-operation in translating Russian periodicals has already been instituted. The American report demands the considered attention in Britain both of the Advisory Council for Scientific Policy and of the Roberts Committee, which is inquiring into the public library service of the country. Apart from this, it should assist the Parliamentary and Scientific Committee and all who realize the magnitude and seriousness of the whole problem to impress on the Government the need for urgent and adequate action, and for an end to the procrastination and delay that for more than a decade have led to the waste of much scientific effort and man-power.

UNIVERSITY COLLEGE, IBADAN

The Birth of Nigeria's University

By Dr. Kenneth Mellanby. Pp. 263+9 plates. (London: Methuen and Co., Ltd., 1958.) 25*s*. net.

THIS is an autobiographical and personal book. It records the part which Dr. Kenneth Mellanby played for six years as the first principal of University College, Ibadan, Nigeria. When he arrived in 1947 the site was a piece of unsurveyed bush. When he left in 1953 it was a flourishing college presenting candidates for degrees in the University of London and with buildings which many British universities might envy.

Dr. Mellanby writes with sincerity and candour. He makes no secret of the fact that some of his policies were criticized both in Britain and in Nigeria. It is still much too early to judge whether he or his critics were right. Nor does it matter in this book who was right. What matters is the record of what it is like to build a university in tropical Africa, written while it is still fresh in his mind by a man who has built one.

When a university begins as nothing more than two or three square miles of uncleared tropical bush, the first principal (Dr. Mellanby says) must regard himself as expendable. He has no council, no senate, to approve his actions. Every day he has to decide either to do something by unorthodox methods or to run the risk that it will not be done at all. Once the apparatus of academic government is set up, the principal of an African college finds himself to be the point of attachment of three forces which rarely pull in the same direction. London provides money for capital expenditure, coupled with liberal issues of advice which the principal cannot lightly disregard. The local government and Press shower criticism (often only for political reasons) upon the principal; this, too, he cannot lightly disregard. And his own freshly constituted and inexperienced council and senate observe him suspiciously for symptoms of autocracy, and test their untried authority by questioning his policies and slowing down the pace of his pioneering efforts: this force, too, he disregards at his peril.

Dr. Mellanby describes (subjectively of course, because he is still too close to events) what it is like to be acted upon by these three opposing forces. He raises questions which are fundamental to the whole experiment of exporting the English university system to tropical Africa. Chief among these is the question of academic standards: Should academic standards for African universities be from the outset as high as academic standards for the University of London? On one hand many Nigerians would indignantly reject the suggestion that an Ibadan B.A. should be lower in standard than a London B.A.: on the other hand, many Nigerians are impatient that, in a country which needs graduates urgently, so few students graduate from Ibadan and such high standards of entry are demanded. This is one example of the massive unsolved problems which accompany the experiment of exporting the University of London to the African bush. Dr. Mellanby's book is a welcome record of the sincerity and enthusiasm of those who took part in founding Nigeria's university, and the sustained help which the University of London has given to the cause of higher education in the Colonies.

E. ASHBY

FROM CONDUCTORS TO TRANSISTORS

Electric Conduction in Semiconductors and Metals

By Dr. W. Ehrenberg. Pp. x+390. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 63*s*. net.

THE scope of work on semiconductors has increased in recent years to such an extent that it is no longer practicable for one book to cover the whole field in detail. Dr. Ehrenberg has therefore wisely confined his attention to transport properties, leaving on one side studies of magnetic susceptibilities and surface adsorption (for example), and giving only little space to questions of absorption and emission of infra-red radiation and of X-rays (5 and 3 pages, respectively). If this restriction is granted, it is convenient to treat the subject under the following broad headings.

First, the theoretical basis of band theory and its experimental checks are discussed. This is fundamental for both equilibrium and transport properties. The author spends Chapters 5 and 6 on this topic (65 pages), half the space being devoted to the wave-mechanical problem. He gives a clear introduction which should enable the reader to pass readily to more advanced discussions. This applies in particular to the author's introduction to Bloch's theorem, which he makes plausible in a very simple manner. It also applies to the concept of Brillouin zones, which are introduced by reference to the simple cubic lattice, rather than by more general arguments.

Secondly, an account is given of electron scattering and times of relaxation. Whereas for band theory one could refer the reader to existing standard texts (though, strangely, this is never done in books on semiconductors), this second topic is characteristic of transport phenomena, since it includes the origin of the electrical resistance of materials. The author treats this subject on pp. 55–63 and in Chapters 7 and 8 (a total of 51 pages). A full account of lattice scattering and of the original treatment of ionized impurity scattering is given here, but neutral impurity scattering receives only a brief mention (p. 244).

Thirdly, armed with this theoretical equipment, the author derives more or less formal expressions for the transport coefficients (conductivity, magneto-resistive ratio, Hall and thermo-electric coefficients, etc.), under various conditions of scattering (Chapters 4 and 9, 35 pages). These may then be compared with experiment (Chapter 10, 54 pages). It is good to see that the author has here not restricted himself to germanium and silicon, but has gone on to discuss the older low-mobility semiconductors, on some of which new work is badly needed. On the other hand, results for metals are scarcely discussed, and topics such as the skin effect in metals are also not treated, so that the term 'metals' in the title could be misleading.

The reader should be warned that some of the results in Chapter 4 appear in unfamiliar guise. The reason for this is that the author gives simple but approximate expressions for the Fermi integrals (p. 38):

$$\int_0^\infty \frac{x^n \mathrm{d}x}{1 + \lambda \exp x} \sim \frac{a_n}{\lambda + b_n}$$

where a_n, b_n are numbers, and sometimes uses these in the standard results. The numerical information concerning the a's and b's is new, and, as an error of less than 5 per cent is claimed for $\lambda > 1/6$, it may often be useful.

Fourthly, the author discusses the non-linear properties of semiconductors which have led to their applications as circuit elements, and which are largely responsible for the widespread interest in the whole field. Dr. Ehrenberg has here made a serious effort to give an account of these developments, and has devoted more than a quarter of the book to them (108 pages). He discusses barrier layers and rectification, excess and minority carriers, their life-times, and various types and aspects of transistors. But space considerations clearly did not allow him to discuss the more complicated flow and space charge regimes in transistors.

Because the book is so broadly based, and because the author has read so widely, this is a most useful book which beginners as well as workers in this field will want to possess. The beginner should note that he has not really wasted his time when, after diligent study to p. 33, he reads "The absurd result obtained here indicates therefore a serious misapplication of the model" or when doubt is again thrown (on p. 81) on the preceding work. It might have been simpler if the author had started with what he regards as a satisfactory model (Chapter 5), and if he had introduced those results of Chapters 2–4 which are in fact needed at the appropriate points in the discussion of this model. This would have obviated the two revisions of the model in the first quarter of the book.

Although the preface is dated January 1958, internal evidence suggests that the manuscript itself was completed by 1956. When a subject develops as rapidly as the one here under review, and when the author has evaluated a great deal of recent information, a delay of two years before publication is achieved must be a matter of regret. In spite of this handicap, this book is one of the most balanced and thorough accounts of this field which is at present available.

P. T. LANDSBERG

PROGRESS IN PHYSICS

Reports on Progress in Physics

Vol. 20 (1957). Pp. iv+568. Vol. 21 (1958). Pp. iv+383. Edited by A. C. Stickland. (London: The Physical Society, 1957, 1958.) Each 63*s*. net.

WITH the increasing pace of scientific research, the collection of information regarding recent advances in any specialized branch of investigation is a formidable task and the demand has therefore grown for detailed progress reports and review articles.

The Physical Society, as long ago as 1934, foresaw the need, and the series of annual "Reports on Progress in Physics", which the Society has published almost regularly for the past twenty-odd years, is now a well-established part of our scientific literature and has reached a standard of perfection which many more recent publications are striving to imitate.

Vol. 20 (1957) and Vol. 21 (1958), the two most recent issues in the series, each contain nine independent articles dealing with various aspects of theoretical, experimental and technological physics. The emphasis seems to be, perhaps unavoidably, on theoretical and nuclear physics. The standard of reporting is high and the authors are all experts on, and actively engaged in, the subjects they discuss. The articles vary considerably in length, not always in proportion to the importance of the topic discussed. Vol. 20 contains a long report of 140 pages by R. H. Dalitz on *K*-mesons and hyperons, and Vol. 21 one of the briefest, a 21-page review by D. M. Brink on the theory of collective excitations in nuclei. Every report is accompanied by a very comprehensive list of references.

All research establishments and many research workers are bound to possess their own individual copies of the "Reports". In addition, doubtless many have also purchased separate copies of particular articles, for these are available in paper covers for purchase at appropriate cheap rates. It is therefore not worth while to discuss in detail in this review the contents of the two volumes, but some general comments and reference to one or two articles may be of value. The editors of the "Reports" have in the past impressed on their contributors the necessity to bear in mind the more general reader in addition to the specialist worker, and therefore to preface their articles with an adequate introduction suitable for the non-specialist physicist and to explain fully and simply all terminology and methods used. Not all succeed in doing this, but it is pleasant to report that in the two volumes under review considerable improvement in this respect has been achieved. One or two articles in each volume have an especial appeal for the general reader. In Vol. 20, for example, the review of methods of high-speed photography by J. S. Courtenay-Pratt is both instructive and enjoyable reading, largely because of its numerous illustrations and clear diagrams but also because of the wide application of the new methods in both research and industry. Similarly, in Vol. 21, the report by R. Fatt on the physics of nerve processes, though perhaps not so easy to read, will attract the attention of the physiologist and biologist in addition to the physicist, and the detailed discussion by W. Lochte-Holtgreven on the production and measurement of high temperatures (with an addendum by R. Schall and F. Wecken on high temperatures obtained with chemical reactions), based mainly on the study of thermally excited plasmas with temperatures within the range 10,000–70,000° K., must inevitably have a wide appeal in these days.

Nuclear, atomic and theoretical physics are indeed well represented; but that does not mean that the classical physicist is neglected. For the classical physicist Vol. 20 provides an article by E. R. Dobbs and G. O. Jones on the theory and properties of solid argon, and for the solid-state physicist, "Microwave Properties of Solids" by D. M. S. Bagguley and J. Owen. In Vol. 21, the article entitled "The Specific Heats of Metals at Low Temperatures" by D. H. Parkinson affords a clear and modern treatment of a subject which has been studied extensively since the beginning of the century. During the past decade, moreover, there has been a great deal of activity in the field of low-temperature calorimetry, and most metals now have been examined in reasonable states of purity at temperatures extending into the liquid-helium range. Specific heats, like most thermal properties, are difficult to determine experimentally with precision, and the specific heat of a substance, being a macroscopic quantity, can give only limited information regarding the finer structure of matter. Nevertheless, the general theory of the specific heat of metals which takes into account the contributions of the specific heat from both the crystal lattice and the conduction electrons, and the thermodynamic derivations governing the specific heat of superconductors, are sufficiently straightforward to be within the grasp of honours-degree students of physics. Hence, not only is Dr. Parkinson's report valuable as a stimulant to the research worker to continue investigations in the field of low-temperature calorimetry of metals and in particular in the determination of the shape and position of the Fermi surface, but it is also an important addition to the text-book discussions of specific heats suitable for the advanced or honours course.

In conclusion, it should be mentioned that in addition to its nine reports, Vol. 20 contains a cumulative author index and cumulative subject index to Vols. 16–20 inclusive. S. WEINTROUB

ORGANIC FLUORINE CHEMISTRY

Aliphatic Fluorine Compounds

By A. M. Lovelace, Douglas A. Rausch and William Postelnek. (American Chemical Society Monograph Series, No. 138.) Pp. x+370. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 100*s.* net.

THE stated purpose of this book is to give complete coverage of all known aliphatic fluorine compounds and to review them comprehensively—a difficult task in this large and rapidly growing field of chemistry. It can be said immediately that this book does not provide the balanced, critical and comprehensive treatise on organic fluorine chemistry that is so badly needed at the present time. The "286 different methods of preparation . . .", "over 60 tables . . .", "physical properties of over 4,500 organic fluorine compounds . . ." summarized in the book are undoubtedly useful; but there is little of the claimed "critical review of the field's systematic progress". The book is a compilation of abstracts of papers and suffers accordingly, summarizing the factual information without propounding the basic reasons underlying the whole field.

The literature is covered thoroughly to 1955, and some 1956 papers are included. The allocation of space among the thirteen chapters (fluorination; alkanes; alkenes and alkynes; alcohols; ethers; ketones, etc.; acids; acyl halides; esters; nitrogen compounds (I); nitrogen compounds (II); organometallics; sulphur compounds) is good and the number of literature references is excellent. The book is well set out and well printed, but in this first edition there are far too many factual, typographical, and proof-reading errors, and clear signs of inadequate checking with the literature; one gets the impression that more use was made of abstracts and a card index system than of the original literature.

Typical errors are as follows: "The bromination of $CF_3CH:CH_2$ at 140° yielded $CF_3CHBrCF_2Br$ and the addition of bromine to $C_3F_7CH:CH_2$ . . . yielded $C_3F_7CHBrCH_2Br$"; ". . . where fluorination of hexafluorobenzene yields $C_6F_6Cl_6$"; "Henne and Zimmer isolated CF_3COOBr and CF_3COOI . . ."; "Roylance, Tatlow and Worthington reacted *o*-dichlorobenzene with CoF_3 and $LiAlH_4$ in ether at 0°"—fortunately they did not, and so live on.

Criticism is always easy, but the presence of numerous errors makes the book difficult to read and often misleading, particularly when errors in physical data occur in the tables. In some places the references are mixed up. One has thus to question continually whether what one has just read is factually correct or not, and how much weight should be given to the evidence. There is no doubt, however, that this could be a most useful compendium, and it is to be hoped that a corrected second edition will soon make its appearance.

R. N. Haszeldine

BRITISH MARINE FISHES

The Observer's Book of Sea Fishes

By A. Laurence Wells. Pp. 160 + 64 plates. (London and New York: Frederick Warne and Co., Ltd., 1958.) 5*s*. net.

This moderately priced little book will enable anglers and others to identify almost all the fishes they are ever likely to meet in British seas, and from that point of view it is a useful addition to a pocket series designed to serve the needs of amateur naturalists and other observers of the things, natural and artificial, among which we live. At the price it may have been impossible to provide an entirely fresh set of pictures, and most of those here were first presented to the public by the same publishers in 1925, in "Fishes of the British Isles" by J. Travis Jenkins. They were not new then, for they were taken from the well-known works of Day (1880–84), Smitt (1892–95) and others. Perhaps it is just as well that a complete set of original illustrations was not attempted, if the unfamiliar (apparently new) coloured pictures on Plates 25 and 36 are fair samples of what might have been. The crude picture of the opah will yet serve for identification, but the misrepresentations of what purport to be corkwing and ballan wrasses will not. The figure labelled corkwing bears but little resemblance to the real thing, while that named ballan wrasse is a travesty of a beautiful fish; it looks as if it might be a copy at second or third hand of the ballan wrasse in Jonathan Couch's four-volume work (1862–65).

The classification and nomenclature are modern but accounts of habits and life-histories are all too often ancient, the author seemingly having derived information too freely and uncritically from Couch (excellent as he was for his day) and other authors of the latter half of last century and the early years of this: he appears to be unfamiliar with much modern work. A few hours in a good library searching through the past thirty or so years of the relatively few scientific English language journals devoted to marine biology and fisheries would have saved him from repeating some hoary legends and would have provided him with much material not yet published in a popular work. Thus, for example, he would have learnt how the angler-fish does use its lure and would not have given what is surely another version of the account by Ælian as quoted by Couch, and he would have been led to modern knowledge of the migrations and breeding of the mackerel. These are but two instances among many which invite criticism.

This book is a lost opportunity, for there is no good modern book, scientific or popular, describing British fishes. There is a very real need for such a book, with authoritative text and new first-class illustrations: the present book provides neither.

D. P. Wilson

MEASUREMENT OF PERSONALITY

Personality and Motivation Structure and Measurement

By Professor Raymond B. Cattell. Pp. xxiv + 948. (London: George G. Harrap and Co., Ltd., 1957.) 55*s*.

In this monumental work, Prof. R. B. Cattell gives a detailed description of the systematic scheme which he has developed for the assessment of personality in terms of the major 'source traits'—those basic personality traits which determine characteristic behaviour and its variations in different individuals.

Three types of data have been utilized: ratings made by associates on forty-two types of behaviour characteristic such as adaptable, cautious, frank, etc.; answers to questionnaires on the same types of behaviour; and scores on a heterogeneous collection of objective tests, including tests of knowledge about interests, predictions of behaviour, perception and recall of related material, projective tests, autonomic reactions and various physiological measures. These data he has submitted to the statistical technique known as 'factorial analysis'; and he terms the factors extracted 'source traits', upon which are based the related types of real-life behaviour and test and questionnaire response. Undoubtedly he has carried out the statistical procedures with enormous care and ingenuity. Some of the factors extracted seem reasonable enough, for example, the motivational tendencies he calls 'ergs', such as 'self-assertion', 'escape', etc. Some of the factors relating to general personal characteristics are also widely recognized, for example, 'cyclothymia versus schizothymia', 'dominance versus submissiveness'; but others are more dubious. However, it is very difficult to accept the existence of some of these 'source traits' as basic personality factors, because of their apparent lack of relationship to the questionnaire and test data from which they are said to be derived. For example, 'premsia', a type of emotional sensitivity which differs from emotional integration, is related to a preference for being a bishop to being a colonel, a lack of physical endurance and a tendency to be brought to tears by discouraging circumstances. Although one can see a possible relationship between some of the personality factors and the associated objective test data, the tests require a much more thorough psychological investigation before their significance to personality can be established.

It is often difficult to follow Prof. Cattell's argument, since it lacks clarity, or to understand how he has used his source data. Though he must be congratulated on presenting a valuable outline approach to these questions, and on the range of data he has amassed; yet far more detailed experimental investigation is necessary before the existence of the 'source traits' and their inter-relationship within the personality is finally acceptable.

M. D. Vernon

Two New Academic Press Journals

Volume 1, Number 1, Spring 1959

EXPERIMENTAL NEUROLOGY

Editor-in-Chief: W. F. WINDLE
National Institutes of Health, Bethesda, Maryland

Associate Editors:

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Volume 1, 1959, 6 issues, £5 14s. 6d.

THIS new periodical will publish results of original research by experimental methods; neurophysiology, pharmacology, and chemistry as well as experimental neuroanatomy, embryology, and pathology are the disciplines to be considered. The Editors believe that development and application to the nervous system of the techniques of electron microscopy and of histochemistry will lead to an increasingly large number of reports of an experimental nature.

Manuscripts in the English language and editorial queries may be submitted to the Editorial Office, Room 3D-14, Building 10, Laboratory of Neuroanatomical Sciences, National Institutes of Health, Bethesda, Maryland, U.S.A.

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LLOYD GUTH and KARL FRANK, Restoration of Diaphragmatic Function Following Vagophrenic Anastomosis in the Rat

C. MURPHY COMBS, Course of Fibers of Brachium Conjunctivum Revealed by Evoked Potential Method

E. J. H. NATHANIEL and C. D. CLEMENTE, Regeneration of Cortical Nerve Fibers and the Fate of Skin and Muscle Grafts Inserted in the Brain

J. M. GIRADO and JAMES B. CAMPBELL, The Innervation of the Urethra of the Female Cat: A Physiological and Pharmacological Study

K. FRANK and J. M. SPRAGUE, Direct Contralateral Inhibition in the Lower Sacral Spinal Cord

Volume 1, Number 1, Spring 1959

DEVELOPMENTAL BIOLOGY

Managing Editor: M. V. EDDS, JR.
Department of Biology, Brown University, Providence, Rhode Island

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Volume 1, 1959, 6 issues, £5

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YASUA HOTTA, SZOZO OSAWA, and TOMOHIKO SAKAKI, Ribonucleic Acid and Differentiation of the Gametophyte of a Polypodiaceae-Fern

ROLF LOOSLI, Vergleich von Entwicklungspotenzen in Normalen, Transplantierten, und Mutierten Halteren-Imaginalscheiben von *Drosophila Melanogaster*

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A GEOMETRICAL APPROACH TO THE STRUCTURE OF LIQUIDS*

By Prof. J. D. BERNAL, F.R.S.

MOST of the vast literature on the liquid state is based on attempted explanations of experimental observations of the thermal, mechanical, and other properties of actual liquids. Compared with the progress of the molecular theories of gases and the lattice theory of crystalline solids, there has been little success in accounting for the phenomena of the liquid state in terms of the position and the known laws of the interaction of their constituent molecules. This is evidently because of the extreme difficulty of arriving at a model of the structure of a liquid which corresponds to the arrangements of its molecules and which at the same time is susceptible to mathematical computation. Most recent theories[1] are frankly attempts to adapt the known structures of gaseous and crystalline matter to the intermediate state of the liquid. They are consequently physically very implausible, whether they are the kinetic multiple molecular contact theories of Kirkwood[2], Born and Green[3], the cell theories of Lennard-Jones and Devonshire[4], the hole theories of Frenkel[1], Eyring[5] and Furth[6], or the cybotactic hypothesis of Stewart[7]. The last three indeed assume that a large part of a liquid consists of crystalline material, which is in contradiction to the essential negative property of liquids—their lack of long-range order.

Meanwhile, evidence on the actual molecular structure of liquids has been accumulating, starting with the classical work of Prins[8] and Stewart[7] based on X-ray, and now on neutron, diffraction of liquids[9], which shows them to possess only a short-range order, practically limited to molecules in the first and second spheres around a given molecule. Very little use has been made of this evidence in constructing theories of the liquid state, essentially because of its complexity—of a kind unfamiliar to theoretical physicists or chemists.

It has occurred to me recently that, in view of this and a renewed interest in the properties of liquids, it might be worth while to take up the sketch of a theory I first put forward twenty years ago[10], and to see whether it is capable of leading to a physically acceptable theory of liquids. I cannot yet claim that it is at the same time adapted to mathematical treatment, but I have hopes that at least it can be adapted to computing machines in the way that has already been used by Alder and Wainwright[11] for kinetic studies of gases.

The essential feature of this theory is that it treats liquids as *homogeneous*, *coherent* and *essentially irregular* assemblages of molecules containing no crystalline regions or holes large enough to admit another molecule. In most of what follows I shall be dealing with ideally simple liquids such as those of the rare gases (except helium), but the arguments used can apply with minor modifications to all liquids. What characterizes any particular liquid arrangement is its radial distribution function $g(r)$ which expresses the probability of finding a molecule at a distance r from any other. The determination of the distribution function from diffraction data is subject to error in detail, but its main features are beyond doubt. All show a strong peak indicating 8–12 neighbours at a distance r_0, very little different from the closest approach in the corresponding crystalline solid. The interpretation of the structures corresponding to any radial distribution function is an exercise of an almost unknown subject, 'statistical geometry', which I recommend to mathematicians. There must be theorems limiting the possible forms of distribution functions of any array of points whatever. For example, in a dense irregular assembly, each point is linked in general by fourteen vectors to its neighbours, while only six are needed to fix its position precisely, each vector being counted twice. It would be most desirable to find the true minimum number of parameters or parametral functions defining the statistical structure of any homogeneous irregular assemblage in the way that the lattice vectors define a regular one. I suggested—but could not prove in my original paper—that three parameters suffice to determine the whole of a distribution function : N_1 the number of neighbours, r_1 the mean distance, and λ_1 the variance of r between the neighbours. Whether this be so or not geometrically, it is evident that physically most of the properties must be determined by the arrangement of neighbouring molecules, on account of the rapid fall-off of attractive intermolecular potentials as $1/r^6$ for apolar molecules.

What I am attempting to do now is to examine more closely the neighbour relations in irregular assemblies of molecules. In any definite assembly of points whatever, the neighbours of any one point can be precisely indicated. If planes are drawn bisecting the distances between each point and any other, then we can call those points corresponding to the sides of the smallest convex polyhedron surrounding the point the *geometrical neighbours* of the point[17]. There seem to be, in irregular as in regular arrangements, some fourteen of these, and in any approximately dense assembly of molecules, they will lie between r_0 and $\sqrt{2}r_0$, where r_0 is the distance of closest approach. In the ball-and-spoke model (see below), this number was found to be 13·6 and in the 'Plasticene' model 13·3.

Many of the properties of liquids can be most readily appreciated in terms of the packing of irregular polyhedra—as in a foam (Fig. 1). For example, the total volume V of a liquid of n molecules is Σv_q, where v_q is the volume of the q^{th} molecular polyhedron. To obtain an expression for v_q, or rather for $\bar{v}$, the mean polyhedron volume, in terms of molecular dimensions and arrangement, it is not convenient to use the number of geometrical neighbours, which is insensitive to these factors. It is easier to use the number N of *physical neighbours* which can be defined, arbitrarily, as those of the geometrical neighbours which lie at distances between r_0 and 5/4 r_0 (for beyond the latter distance the Van der Waals attraction falls to less than a quarter of its maximum value). The mean volume can then be expressed as $r_0^3 \mathrm{f}(N)$, where $\mathrm{f}(N)$ is a function not yet

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* Substance of a Friday Evening Discourse at the Royal Institution on October 31.

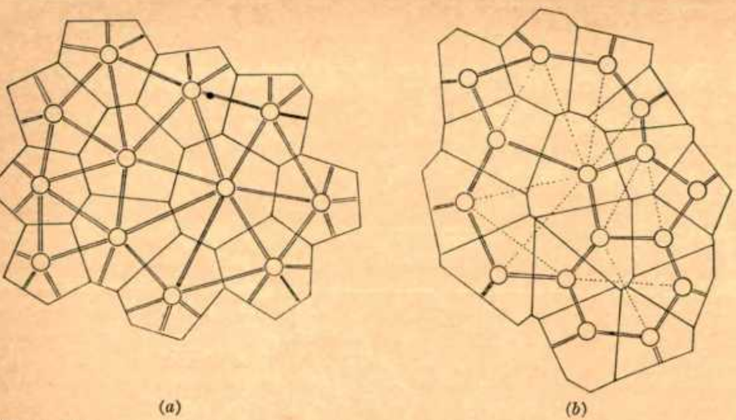


Fig. 1. Diagram of neighbourhood polyhedra, geometrical and physical, for two-dimensional arrays of points. (*a*) High co-ordinated; =, physical neighbours; (*b*) low co-ordinated; ...., geometrical neighbours

determinable for the case of irregular packing, but which cannot differ widely from its value in regular packing as shown in Table 1.

Table 1

N	12	10	8	6	4	3
$f(N)$	5·66	5·9†	6·4†	8	12·3	18
$f(N)/f(12)$	1·0	1·04	1·16	1·41	2·17	3·18
T^*	0	0·8	0·9	1·0	1·2	1·27
		T_m				T_c

† Interpolated values

The equivalences of N with reduced temperature T^* are derived from de Boer's results (ref. 20).

The irregularity of the neighbourhood polyhedra is the essential condition for liquid as against crystalline structures. It can be seen to underly their thermal and mechanical properties. It implies first of all the absence of long-range order and of symmetry other than statistical. The conditions that a set of quasi-equal irregular polyhedra must satisfy to fill space completely must be stringent, but I have not been able to define them mathematically. Instead I have tried to approach them by physical and mathematical model-building in a somewhat different way from that employed by Morell and Hildebrand[12]. In the first place, I have constructed models of balls and spokes as irregular as possible using spokes of lengths from 2·75 to 4·0 in. in the proportions roughly the same as observed in liquid distribution functions (Fig. 2). From such models it is possible to draw conclusions on volume and energy of the corresponding arrangements of actual molecules. I have also built models from which the human element is eliminated so far as possible by 'Monte Carlo' constructions. The first of these which I attempted ten years ago was purely mathematical. I operated on a pseudo-lattice with a possible cell content of 100 unit spheres in close-packing. Into this I inserted such spheres in random positions, rejecting all those that would foul earlier positions. After inserting less than fifty spheres there was no room for another. Hence the volume per molecule was more than twice that in close-packed arrangement. This led me to abandon the effort, for it was clear that this random-packed assembly could not be the model of a liquid of volume only 10 per cent more than close packed. I see now it was the model for a liquid approaching its limit of coherence at, or above, the critical point.

The second 'Monte Carlo' approach I have tried with physical models is analogous to the formation of irregular close-packed liquids by compression from a gas. A set of points is chosen at random in the large cell of a two- or three-dimensional lattice (Figs. 3 and 4). If these are thought of as being rigid spheres of unit radius, the compression of such a cell is exactly equivalent to expanding a sphere surrounding each point. No new points are added. Starting with the nearest pair, the points are moved apart by small successive stages so that at each stage no two points are nearer than a pre-specified distance. There is a limit to the process, however. At a length corresponding to about 0·9 of the close-packed distance in two dimensions and 0·95 in three dimensions, no further movement is possible without introducing long-range order. In other words, at densities beyond a certain limit, only crystalline arrangements of incompressible spheres are possible. Two-dimensional

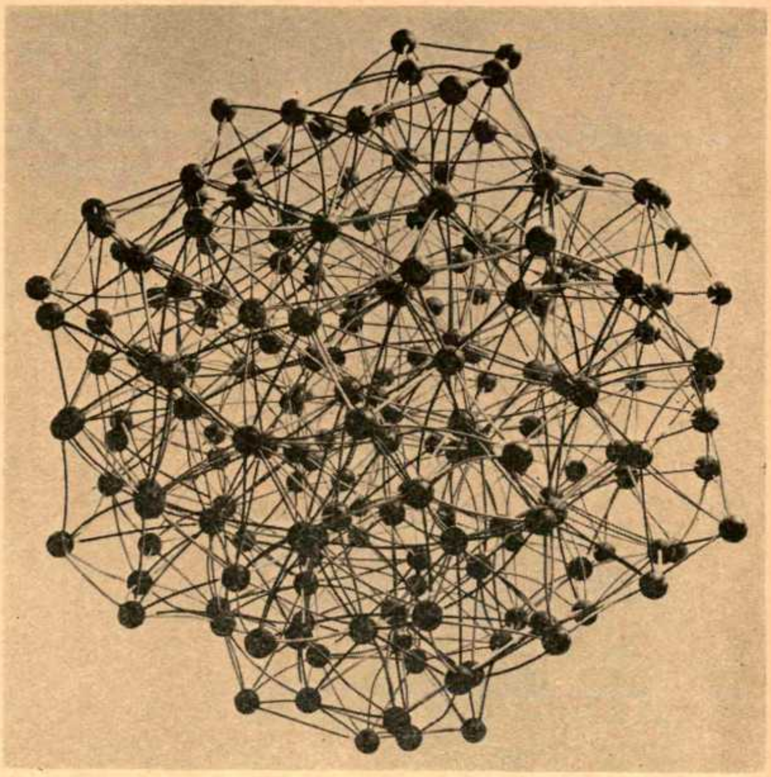


Fig. 2. Photograph of ball-and-spoke model of irregular structure. Spokes of different length are distinguished by colours

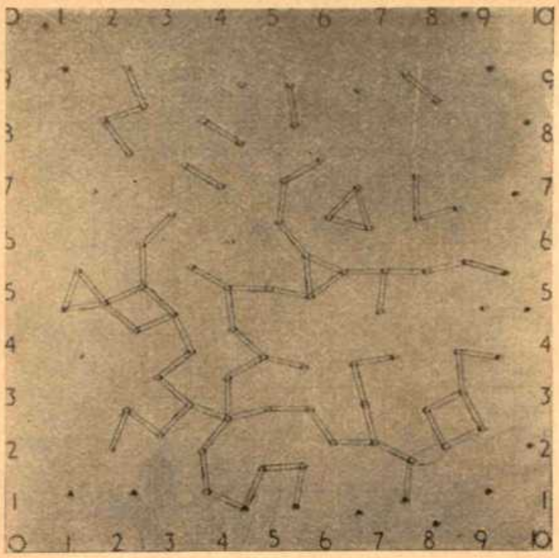


Fig. 3. Two-dimensional random/crystal model at intermediate stage. No two points are at a distance smaller than the 8-cm. long links joining most of the points

aggregates crystallize more easily than do three-dimensional aggregates. This is a point of the greatest importance, because the possibility of irregular co-ordinations are multiplied in three dimensions. The whole process of compressions can be carried out by rules adapted to the iterative action of an electronic computer; but this has yet to be done, and it may turn out to be blocked by the occurrence of impossible moves or 'moving corner' ambiguities. However, enough has been done to bring out clearly that indefinite irregular assemblies can be constructed having about the same volume, internal energy and distribution function, as tested by the Lipson diffractometer, as simple liquids. The possibility of forming such statically stable, dense irregular molecular aggregates in three dimensions follows indeed from the great variety of polyhedra of 10–14 sides that can be escribed about the same sphere. Such arrangements, though they must have slightly greater energy than the corresponding regular assembly, are so much more numerous as to provide for greater entropy.

I have also attempted to describe the irregular character of such distributions both mathematically and by models. I am reasonably sure that the enumeration of topologically distinct convex polyhedra having in general three edges meeting at a point must have been carried out by some mathematicians, though I cannot trace it. The subject appears not to be of interest to modern mathematicians, and I have found little on it later than Cayley[13] and Kirkman[14], who were only interested in symmetrical solutions, except in the very valuable studies of Toth[15]. The derivation of the irregular polyhedra is straightforward but tedious. There are certainly 46 distinct polyhedra with up to 12 faces composed of polygons of 4, 5 and 6 edges (Fig. 5). There are probably, though I have not exhausted the list, some 150 of up to 14 faces. To work out the angles and closest approach of spheres to all these would be a formidable task. Before attempting it I thought it would be well to discover which of them were likely to occur in nearly close-packed assemblies of spheres. For this I used a rough empirical method adapted from that developed by the botanist Marvin[16] to determine the shapes of cells in plants. Balls of 'Plasticene' rolled in chalk were packed together irregularly and pressed into one solid lump. The resulting polyhedra (Fig. 6) were analysed for arrangement of their polygon faces, with the results shown in Table 2. Two results are noticeable: first, the wide variety of polyhedra—the 65 studied showed 32 different combinations of polygonal faces and only two were found with the same permutations of these faces; secondly, the absolute predominance of pentagonal faces. In all but six cases, no polygon appeared more often than a pentagon. These observations, taken together, are the key to the geometrical nature of irregular aggregates of equal spheres and also, in my view, of the molecular arrangements in liquids. Regular three-dimensional arrangements have symmetries limited to multiplicities of 2, 3, 4 and 6. Pentagonal arrangements can only occur in very complex structures such as some of the alloy structures classified by Frank[17].

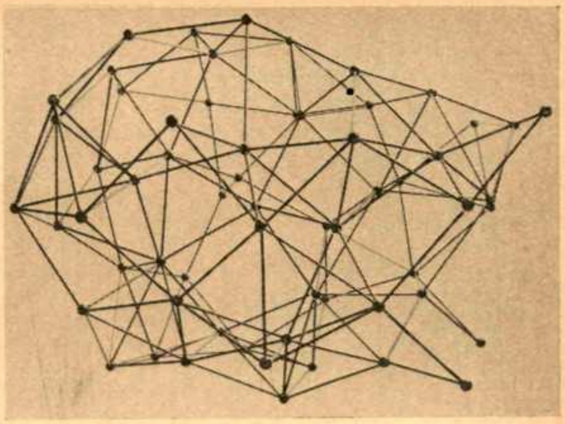


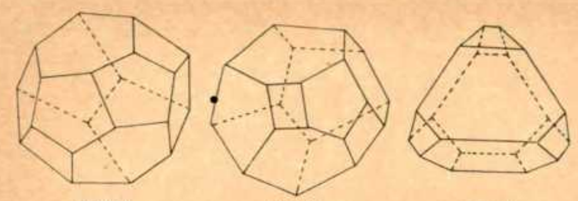
Fig. 4. Three-dimensional hanging-ball model at intermediate stage

Table 2. NUMBER OF EACH POLYGON COMBINATION TYPE ARRANGED IN THE ORDER OF THE NUMBER OF PENTAGONAL FACES

Number of pentagonal faces :									
12	10	9	8	7	6	5	4	3	1
0 12 0 (2) 0 12 2	1 10 2 (4) 1 10 4 (2)	1 0 9 3 2 9 5 1	2 8 1 (2) 2 8 2 (3) 2 8 3 (3) 2 8 4 (4) 2 8 6	3 7 2 1 (3) 3 7 3 1	3 6 2 3 6 3 (5) 3 6 4 (5) 3 6 5 (3) 3 6 6 (5) 4 6 4 2	1 2 5 3 4 5 3 1 4 5 4 1 (2)	1 3 4 3 1 1 3 4 4 1 (2) 1 3 4 5 1 (3) 1 3 4 6 1 4 4 2 4 4 4 4 4 5 4 4 6	5 3 3 1	1 4 1 5
3	6	2	13	4	20	4	11	1	1

Total number of polyhedra, 65. Number of polyhedron categories, 32

Explanation: The numbers for each polyhedron are put in the order of the polygonal faces. For example, 1 3 4 5 1 stands for a polyhedron with 1 triangular, 3 quadrangular, 4 pentagonal, 5 hexagonal, 1 hepagonal face. The last row gives the number in each category.



282(2) 363(1) 525(m)

Fig. 5. Three typical polyhedra with twelve faces

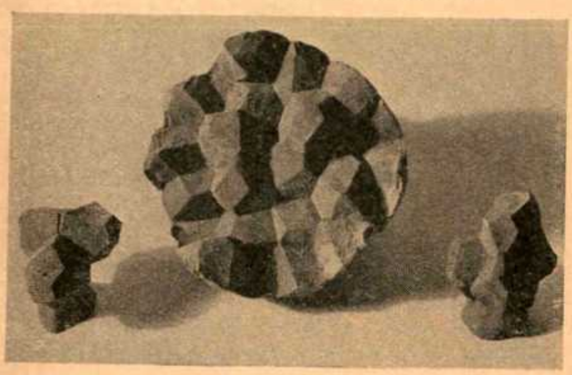


Fig. 6. 'Plasticene' hemisphere showing polyhedra

My central geometrical thesis is that *irregular dense packing and pentagonal arrangements are necessarily connected*. Though I have no proof of this theorem for lack of an adequate statistical geometry, I think it is related to two simple geometrical facts: first, that twelve spheres touching an equal sphere are most regularly distributed in a way in which one just fails to touch five others in its shell—it has a surface co-ordination of 5, to follow Frank's terminology. This results in a pentagonal icosahedron, a shape which cannot be used to fill space. Secondly, in those forms which can fill space, the twelve co-ordinations corresponding to hexagonal or cubic close packing, each sphere is in actual contact with only four others in its shell, a very stable but improbable arrangement. This is on the basis of a rough examination of the number of possible arrangements of 10–15 circles on the surface of a sphere. This may be susceptible to exact statistical treatment, or could be adequately worked out on a computer.

The irregular dense arrangement occupies a volume per sphere of some 10 per cent more than close packing. This is the figure first found by Osborne Reynolds[18] in his studies of the dilatancy of close-packed sand.

I have always found it impossible to construct irregular arrangements of any intermediate density. I believe this is a necessary consequence of the irregularity, and that there is *an absolute impossibility of forming a homogeneous assembly of points of volume intermediate between those of long-range order and closest packed disorder*. Regular and irregular close packing are evidently arrangements of quite different local co-ordination, and a transition between them is necessarily as abrupt as that between two regular phases of different structure such as occurs in the α-(body-centred) and γ-(face-centred) phases of iron.

Translated into physical terms, this geometrical difference expresses the absolute discontinuity between the liquid and the crystalline phases and accordingly the need for a first-order transformation between them. This is in accord with Simon's general findings[19] that the melting entropy of solids increases indefinitely with the temperature, showing therefore no tendency towards a critical point. The fact that the polyhedra of irregular and regular packing differ only slightly in volume for the same values of N would seem to justify, at least as a working hypothesis, the idea that a liquid structure near the melting point is only an irregular but absolutely distinct variant of a crystalline one. In this irregular structure, molecules are vibrating about positions of equilibrium for times so long compared to their period of vibration that for all thermal properties the time variations of molecular positions—so important for all transfer phenomena—can be neglected in the first instance. The lower specific heat of simple liquids compared with the corresponding solid at the same pressure is accounted for by the irregular and wider shape of the equilibrium minima: at constant volume there is little difference between the specific heats of solids and liquids. On this basis, finding the equilibrium structure of a liquid is the same as finding that of a crystal. For liquids having molecules with attraction rapidly diminishing with distance—such as rare gases and organic liquids, but not for liquid metals or water—the solution equates minimum energy with minimum volume. If the internal energy U varies as $1/r^6$, it must vary as $1/v^2$, as Van der Waals had intuitively supposed. The types of irregular arrangement arrived at by all the methods described above, except that leading to maximum coherent volume, are of minimum volume and should be near to true models for a liquid near the melting point. Indeed, by using a potential function of the form $U = \frac{A}{r^{12}} - \frac{B}{r^6}$ they are found to give the right orders of magnitude for the heat of fusion.

The chief advantage that a theory based on the intrinsic irregularity of liquid structures has over most cell or hole theories is that it gives a natural qualitative explanation for the high entropies of liquids compared with solids which these theories have failed to do, as de Boer[20] has pointed out. Unfortunately, it is not yet possible to put this on a quantitative basis. The fundamental difficulty is to know what to count as a configuration in order to build a partition function. It is evident that in an irregular structure there is a wide variation in the potential energy associated with each molecule. The extent of this variation, drawn from the first model structure and from the 'Plasticene' polyhedra, is shown in the histograms (Fig. 7).

It may be possible to make use of these differences to build a partition function somewhat on the lines advocated by Kikuchi[21] for another liquid model; but even without this, we can make a qualitative picture of the energy states in a liquid as a function of temperature. In the first place, from near the melting point downwards through the range of supercooling, the approximate close-packed disorder is maintained, for it cannot change without crystallization, which, for the reasons already given, is always a discontinuous phenomenon. However, at all temperatures the thermal state of a liquid is fundamentally different from that of a solid, for the rise in temperature leads not only to higher vibrational levels, as it does in a solid, but also to changes in the equilibrium configuration, increased disorder, and, at constant pressure, also to greater volume, lower co-ordination numbers and consequently lower mean-lattice energy. A liquid, over this range of temperature, corresponds more to a series of polymorphic phases with heats of transformation between them

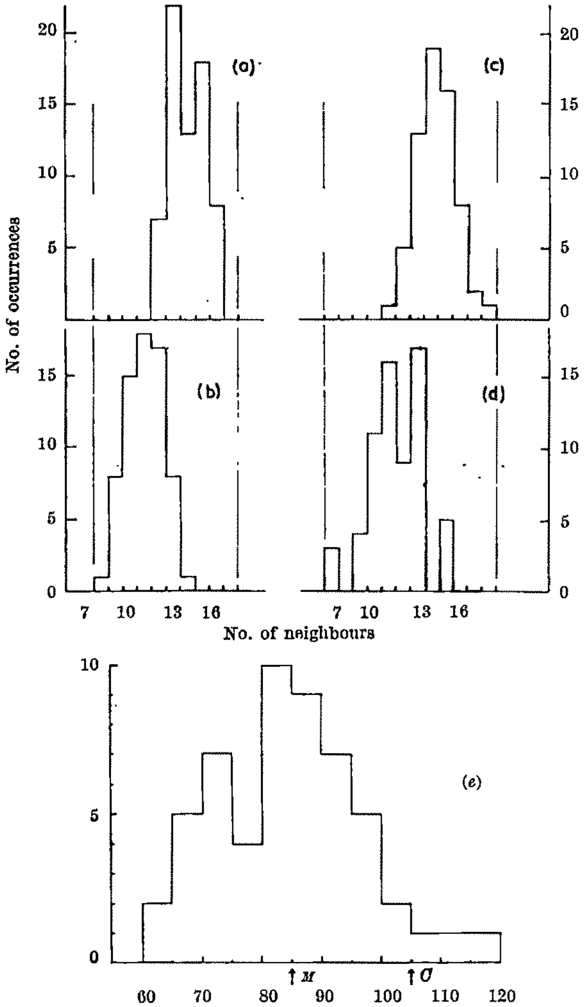


Fig. 7. Histograms of (*a*) geometrical and (*b*) physical neighbours derived from 'Plasticene' polyhedra; (*c*) and (*d*) derived from the wire model. (*e*) Distribution of energy between balls in wire model in arbitrary units. *C*, energy of corresponding crystal; *M*, mean energy of liquid

than to a single phase, as explained in my original paper[10]. Instead of heats of transformation, the process is smeared out to give an accelerated rise in the specific heat at constant pressure which I called the 'configurational specific heat'.

This has been recently studied in detail by Jones and Walker[22] for liquid argon. Their observations of the specific heat seem to me of fundamental, but hitherto unrecognized, importance. They find that, well above the critical pressure, the specific heat at constant pressure, starting at 10·8 cal./mol./deg. C., increases rapidly with temperature to values of nearly 50, reaches a sharp maximum and then falls to the normal value 3 for a gas. This is the condition for a higher-order transition (λ-point) between the liquid and the gaseous state. The line of transition in the pressure-temperature diagram continues that of the boiling-point line indefinitely beyond the critical point. I would suggest calling this line the *hyper-critical line*. Its existence shows that liquid and gas do not form, as previously thought, a single 'fluid' phase. They are distinct states of matter, though one may pass into the other without visible discontinuity. (The discontinuity is, however, 'audible', as shown by heavy absorption of sound in this region and is also shown by a minimum in the velocity of sound and in the viscosity.) This is probably a very general phenomenon applying not only to all liquids and gases but also to all critical mixtures above their critical points.

It finds a ready explanation along the lines of the theory I have just been putting forward. In this picture, a liquid will continue to expand with temperature until it is slightly more than three times its original close-packed volume. The *physical* co-ordination number falls to between 4 and 3, which is the limit for 'coherent' structure—one in which the molecules are linked together without a break throughout the whole volume (Table 1 and Fig. 8). Above the hyper-critical temperature it becomes 'incoherent', consisting of associated groups of molecules in free space. As this temperature is approached, therefore, at constant pressures at or above the critical pressure, more and more co-ordination links are broken, leading to a rise in specific heat. This falls again beyond the hyper-critical point as fewer and fewer links remain to be broken. Just below and above this temperature, the number of intermolecular links undergoes no abrupt change; hence there is no heat of transformation, but continuous regions become discontinuous and vice versa. This is analogous on a micro-scale to the sharp transition between oil-in-water and water-in-oil emulsions. At temperatures and pressures approaching the critical point, the coherent–incoherent structures become also inhomogeneous with macroscopic cavities and drops leading to the critical opalescence, the study of which has been recently taken up again by Debye[23].

The fundamental structural characteristic of liquids—the irregular arrangement of their molecules—can be seen also to be the basis of their characteristic physical property—their fluidity. In a way impossible for a crystalline solid, the neighbourhood relations of molecules in a liquid are necessarily in continual flux. This is easiest to understand by considering the relationships of the polyhedra which define the closest interacting neighbours. The elementary process by which a molecule loses a neighbour is represented by the closing in of the face common to both; how it gains another is by the opening up of a new, in general, triangular face (Fig. 9).

Such processes must occur constantly by thermal motion on account of the sustained inequality of energies between molecules. By repetition they give rise to self-diffusion and show themselves on the macroscopic scale in fluidity. In this view, the *fluidity of a liquid is a consequence of its molecular*

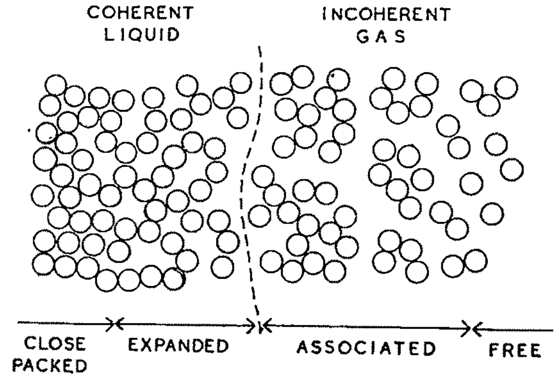


Fig. 8. Diagram of transition of molecular arrangements passing from close-packed liquid to gas through the hyper-critical line

irregularity and not vice versa. The construction of a theory of viscosity based on such a mechanism would be formally almost identical with that of Eyring[5], based on the hole theory and the analogy to rates of chemical reaction. Another consequence of the intrinsic irregularity of liquid structures is their powers of accommodating molecules of different sizes, and consequently accounting for the solvent powers of liquids and their mutual miscibility.

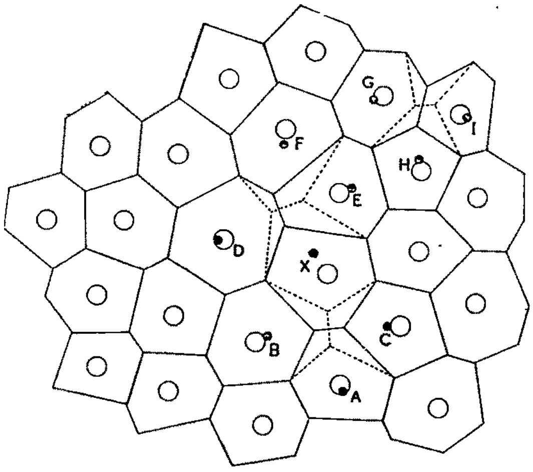
This picture of the liquid state, based on the properties of the simplest spherical molecules such as those of the rare gases, is readily extended to other types of liquid. It can take into account the effects of shape, as in most organic liquids (for example, it would explain the quasi-crystallinity of two-dimensionally packed long-chain hydrocarbon molecules); the presence of hydrogen bonds, as in water, alcohols and acids, leading to the formation of non-equilibrium liquids or glasses; the presence of oppositely charged ions, simple or complex, as in fused salts where low co-ordination[24] also leads to glasses; and that of free electrons, as in metallic liquids where, as I have already proposed[25], the metal ions occupy a smaller part of the volume, leading to greater fluidity and smaller change of volume on melting.

This theory, or rather sketch of a theory, of liquids is put forward not because it accounts better for their properties than the numerous formal mathematical theories that have been in use in the past twenty years. The success of many of these, often radically different from each other, only goes to show how insensitive to theory are such expressions as the equation of state or the laws of viscosity. I am putting it forward rather because, as a crystallographer, I find it more satisfactory to try to build theories of liquids on the basis of a model of an instantaneous molecular structure that is at least plausible. I feel that we now have ample evidence that the essential nature of the liquid state is the existence of statistical molecular configurations with varieties of co-ordination patterns geometrically necessarily different in kind from any that can occur in a regular solid. Any theories that do not take this into account—and few have hitherto—are likely to lead to predictions which are the wider from the facts the more the properties concerned, such as vapour pressure or critical constants, depend directly on the molecular arrangements.

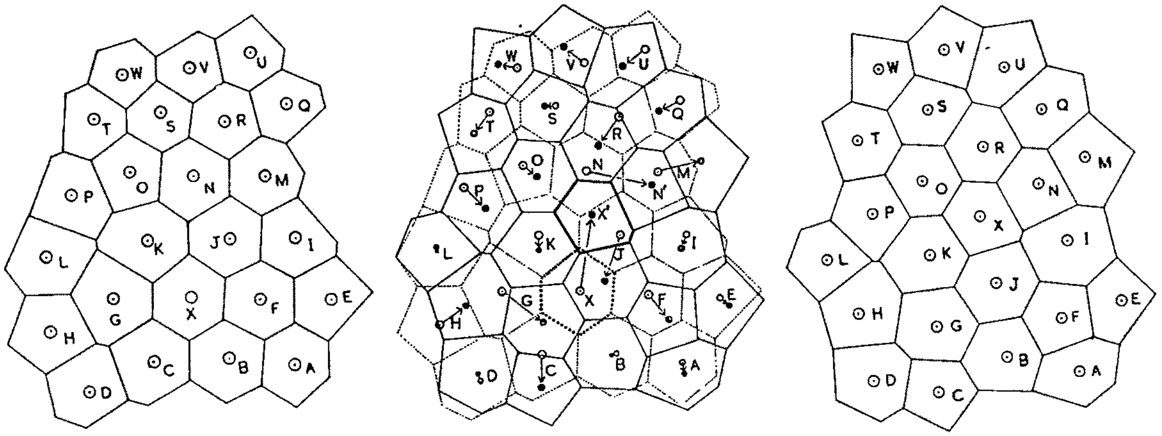
What I have done, and I hope even more the programme of research that should follow it, should show that an approach to a theory of liquids based on irregularity is not so formidable mathematically as to discourage quantitative studies. If this should prove to be the case, it seems probable that the new theory should not only explain known facts but also point the way to unsuspected new phenomena.

Note added in proof: Prof. F. C. Frank has directed my attention to the important papers by C. S. Smith[26] and L. J. Meijering[27] on the shapes of crystals in a polycrystalline solid. The former, by experiment, finds the average number of geometrical neighbours to be 12·48; the latter calculates, by an elegant method, that for a completely random distribution of nuclei it should be $48/35\pi^2 + 2 = 15{\cdot}54$. This is clearly greater than the numbers observed and would seem to indicate that the distribution of nuclei is not random. This, however, does not affect the argument above, for the *average* number of edges on the faces of such polyhedra only varies from 5 to $5\frac{1}{4}$ when the number of faces changes from 12 to 16. An alternative version of the general thesis of the paper could be put in the following form:

"In the most probable arrangements of densely packed spheres the *mode* of the surface co-ordination will be the same as the *mean*, or nearly 5. As this



(a)



(b)

Fig. 9. Diagram to illustrate molecular movements in liquids through neighbour exchange: (a) illustrating individual moves; (b) illustrating the extent to which one molecule can be displaced after five moves. (The two-dimensional representation greatly exaggerates the distortion required for a single move)

is incompatible with long-range order, the corresponding arrangement of molecules must be a fluid."

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INTERNATIONAL CONFERENCE ON SCIENTIFIC INFORMATION

THE National Academy of Sciences–National Research Council in Washington was co-sponsor with the U.S.A. National Science Foundation and the American Documentation Institute in arranging an International Conference on Scientific Information during November 16–21 in the Mayflower Hotel, Washington. The Conference opened with an address from Sir Lindor Brown, biological secretary of the Royal Society, and this was followed by a series of sessions, each of three hours, devoted to a section of the Conference subjects. The purpose of the Conference was to bring together scientists and information specialists for discussions of current research and problems concerning primarily the storage and retrieval of information. This is a narrow scope compared with the Royal Society Conference on Scientific Information Services held in 1948. Nevertheless, preprints of seventy-five papers occupying 1,420 pages were circulated to all participants some weeks before the Conference. These participants numbered about one thousand, and for the purpose of facilitating discussion the authors and members of seven discussion panels, each of 9–13 persons appointed well in advance of the meeting, were grouped in a forward section of the Conference hall and permitted to comment throughout the meeting. The remainder of the participants were silent observers during the sessions, but there was ample opportunity for discussion outside the Conference hall and in the neighbouring hall, which housed an exhibition of modern storage and retrieval systems devised by commercial organizations. A small historical exhibit illustrating the Royal Society's long and continuing interest in scientific information services was also on view. Arrangements were made for organized visits to institutions in Washington concerned with the retrieval of information. These included the Library of Congress, the U.S. Patent Office, the National Bureau of Standards Data Processing Systems Division, National Library of Medicine, the Department of Agriculture Library and the Institute of Languages and Linguistics of Georgetown University, where a machine translation of Russian texts in organic chemistry using an I.B.M. 704 computer was demonstrated.

Sir Lindor Brown in the opening address directed attention to the desirability of discipline and restraint on the part of the authors of scientific papers. He said there is much scientific literature which need never be produced, and of that which justifies its appearance 80 per cent could be improved by drastic reduction in length and by clear writing. He urged scientists to publish the results of their work once and once only, and not in a multiplicity of guises. He went on to say: "However we improve the raw material of information there will still remain poor papers, unnecessary papers, trivial papers and repetitious papers. What are we to do with them? What is to be stored? Is it the fruit of the tree of knowledge or is it the fallen leaves? For my part I should be happy if the fruit only were preserved, as I cannot conceive of any collecting and storage system adequate to cope with the world's output of scientific information as it grows at present, and I view with only a little compunction the prospect of the loss of minor contributions to knowledge provided that the ripe fruit can be preserved. The few fallen leaves of my own work are already losing their individuality as they dissolve into the rich compost of the background knowledge of the rising generation. Their individuality is lost, but they have contributed a little to the vigour of the pushing young shoots at the top of the tree—and of course I have a fruit or two up my sleeve still. Of course we have the difficulty: Who is to decide what is the fruit and what is the fallen leaf? Can any information service work on an eclectic principle? I think it can. But only with the full co-operation of the user and the maker of information".

As mentioned above, the primary purpose of the Conference was discussion. No attempt was to be made to arrive at conclusions in the form of recommendations. The Conference certainly achieved its objects of exposing the problems of retrieval of information and of bringing the interested parties together. Although each panel was at liberty to deal with its subject in its own way, the general procedure adopted was to assume that the papers had been read; the panel members then commented on the subject, referring to papers as desired, and a period of general discussion followed.

Panel 1 concerned literature and reference needs of scientists. The papers chiefly related to surveys of information requirements of scientists in a variety of different research organizations, and methods by which research workers find information. A fact brought out by the papers was that communication of scientific information is done as much through personal conversation as by reading the literature. It was stated that the volume of scientific literature is doubling every seven years. It was evident that it is impossible to make generalizations in methods of communicating information and that not only do methods vary from subject to subject but also from user to user and according to the uses to which the information is to be put. Studies on the habits of scientists in acquiring information are still imperfect, but may be the bases for action in certain local situations. The present services go a considerable way towards meeting the needs of the competent research worker in his own field, although the use of abstracts seems to be on the decline and the research worker is not so well served when he wishes to explore a field other than that with which he has some familiarity. The importance of the unplanned contact with new scientific information was stressed.

A plea was made for more studies of the physiological nature of recognition and memory. One contributor urged that neurones as well as electronics have a role in the retrieval of information. Reading-rates of students of about equal standard were reported to vary from 2·5 to 9·8 words a second, and further studies on this and the related problem of reading and visual fatigue were suggested as a fruitful field of investigation.

The second Panel discussed the effectiveness of abstracting and indexing services. The discussion reploughed familiar ground in relation to authors' abstracts versus non-author abstracts, informative abstracts versus indicative abstracts, the role of highly centralized general abstracts (as in Moscow) and specialist abstracts (as in the Commonwealth Agricultural Bureaux), and little that was new emerged. One study, however, reported that in spite of all that is said about biasing abstracts for particular classes of readers, there is a growing tendency by many abstracting agencies to use authors' abstracts. There seemed to be a generally favourable opinion that if authors' abstracts are properly edited they can be of considerable service, and the action taken by the Abstracting Board of the International Council of Scientific Unions in encouraging this in physics abstracting was supported. On the other hand, the delays in issuing some abstracts is becoming so great that in rapidly developing subjects they are of little use for current awareness, and alternative means, for example the quick circulation of the titles of papers as in *Current Chemical Papers*, will have to be investigated. The importance of indexing was stressed by Dr. E. J. Crane, of *Chemical Abstracts*, and in commenting on the possible use of mechanical aids in abstracting he warned against the danger of departing from existing high standards in abstracting and indexing.

The third Panel was concerned with the effectiveness of monographs, compendia, and specialized centres. Some time was devoted to discussing reviews, and it was generally agreed that an insufficient number of first-rate people are willing to give time to their compilation for the benefit of a variety of users—the specialist, the specialist in related fields, the teacher and general reader. The suggestion was made that review writing should be a joint effort of a junior who did the searching of the literature and an experienced scientist who would provide the necessary critical judgment. The review should preferably deal with concepts and leave data to special compendia. The writing of monographs seems to be going out of fashion, although it remains important in biology. An experiment in the U.S.S.R. was described where the Institute of Scientific Information plans to issue a series of monographs attempting to cover the whole field of science: the Russian definition of a monograph is a scientific work which concentrates and develops all aspects and facets of a given scientific discipline and requires strict objectivity from the author. The chief difficulty will be the shortage of suitable authors.

Dr. E. Pietsch, director of the Gmelin-Institut, Germany, described in detail the organization of the "Handbuch für der Anorganische Chemie", where the evaluation of the data is by far the most costly operation in preparing the text. The eighth edition will consist of 60,000 pages and will cover two hundred years of the subject up to 1950. If the "International Critical Tables" were to be re-issued on the same lines as twenty-five years ago, it might require several hundred volumes. The issue of abbreviated tables of data in the form of handbooks for specific uses was strongly urged, and a suggestion was made for increased use of directories of scientific workers and their interests to assist the communication of information. There was also some discussion on the increased use of technical reports, only a fraction of which, however, is abstracted in the abstracting journals because the editors of the latter consider the technical report to lack the careful preparation imposed on the writing of a paper for a journal and because a report, or part of it, is liable to be published again as a paper. The need to give greater emphasis to the value of books in information services was stressed.

A variety of national scientific information centres were described; for example, those in the U.S.S.R., India, France, Japan, Czechoslovakia and Poland. A novel feature of a Czechoslovak service is that all inquiries must be made by telephone, as it is thought that only by this means can the inquiry be sufficiently well defined by discussion to make the information service really efficient. The Soviet representative advocated the centralized information centre and quoted Vavilov as saying that "the contemporary man of research is in the same position in relation to the holdings of libraries of the world as the gold prospector faced by the jungle". The centralized institute dealing with national and international scientific literature was adopted in the U.S.S.R. because all knowledge is organically interconnected, and in one institute, where are concentrated specialized personnel, all collective data, etc., knowledge from one field, for example, physics, can be readily related to other fields such as chemistry, biology, metallurgy. In Poland, where there is an information service in applied science, only the central direction is concentrated in Warsaw and a decentralized system, using eighty different regional institutions and a hundred or more industrial centres, is found to be effective in providing an organized person-to-person contact.

Panel 4 considered the organization of information for storage and search, and devoted some time to the comparison of the characteristics of existing systems. It was considered that, at present, each specific problem requires a system tailored to the special demands on it and the need for further experiment was admitted. Where machines have been used, it seems too early to generalize on their merits or demerits, and consideration of the replacement of the human brain by a machine in a system of retrieval only emphasized the need for any machine to have a good master.

Panel 5 discussed the organization of information for storage and retrospective search. There were twenty preprinted articles in this section, many dealing with the classification or coding of information in specialized fields, in such a way as to enable mechanical retrieval. Words were regarded as being too imprecise for large-scale mechanical information retrieval, and it was suggested that a rigorous mathematical theory of systems should be sought for future development. Further study was proposed of language and the nature of communication—a multi-stage process with the interplay of ideas in a highly unorganized state. In the meantime, the solution of narrow practical problems seemed the more profitable line of advance. Even with a high-speed machine of long memory, the intellectual problem of searching the literature will remain. Machines require careful programming, and it was stated that all they can achieve is to do clerical work more quickly.

Panel 6 concerned itself with the possibility of a general theory on the organization of information for storage and retrospective search. This gave rise to a great deal of discussion, and for those who are expert in one or more systems this may well turn out to have been a profitable occasion, for it appeared that no existing theory can be directly applied, and much more experiment, discussion and thought will be necessary before a general theory can be evolved. The greatest difficulty is to provide for the interaction between the inquirer and his information sources ; thus, any general theory must accommodate the learning process and the consequent need to modify itself continuously. It seems likely that, with so much interest in the subject, something constructive may emerge within the next few years.

Panel 7 covered a wide range as it discussed the responsibilities of governments, scientific societies, universities and industry for improved information services and research. The Panel took an early opportunity of pointing out that the only indispensable person in the whole subject is the scientist, and that through his societies he is the principal maker and user of scientific information. Scientific societies should, if possible, be self-supporting in the publication of original work, but any help required in the secondary information services should have government support, as scientific information is a national resource. As a user, the specialist usually organized his own search, and it was suggested that universities might encourage, more than is done at present, young research workers in learning how to use the literature of their subject as well as how to produce it by the better writing of their papers. Scientific societies might encourage authors not only to submit abstracts but also provide key index words to facilitate the editing of abstracts and indexing.

Nowadays some national governments are large-scale users and producers of information and have responsibilities for its proper distribution. This varies from the small country with a relatively recent acquaintance with scientific research, where information services receive their main support from international agencies, for example, from Unesco through a regional office, to large scientifically advanced countries where national funds are provided on a large scale and where government agencies provide a plan for stimulating and supporting scientists and engineers in dealing with information problems. Whatever method is employed, the whole-hearted co-operation of those who produce the information is necessary.

In the international field the work of the Abstracting Board of the International Council of Scientific Unions was cited as a good example of co-ordination of existing services. The Panel was not in favour of trying to establish an international scientific information centre at present, but rather favoured the co-ordination of national services, for example, through national library services. The trend should be towards more national centres and more international co-ordination. A statistical survey of the economics of the various types of national centres would be helpful in this connexion.

There were no formal conclusions of the Conference, but hopes were expressed that some more formal international organization might follow, possibly through national academies of sciences. Whether this happens or not, the participants in this International Conference on Scientific Information were stimulated by attending it, and it will not be surprising if they in turn stimulate further action towards a renewed consideration of the many and growing problems of scientific information services in their respective countries. That those concerned in the United States are active is obvious.

D. C. Martin

OBITUARIES

Sir Hubert Wilkins

The death occurred in New York early in December of Sir Hubert Wilkins ; he was seventy years old. He will be remembered as a pioneer both in arctic and in antarctic travel.

Wilkins first visited the Arctic as second-in-command of Vilhjalmur Stefansson's Canadian Arctic Expedition which went north in 1913. Wilkins remained a member until 1917 and during these years he became expert in travel on arctic pack-ice. He himself, however, was always keener on air travel and was probably the first man to fly in the Antarctic. His flights in the Arctic, after more than one attempt, culminated in 1928 in an adventurous journey from the north of Alaska to Spitsbergen, for which he received the Founder's Medal of the Royal Geographical Society. His arrival in the latter region stirred the people of Great Britain as no other arctic flight had done. He wrote an exciting dispatch describing the journey for *The Times* ; it was one of the best travel reports ever written.

An important feature of Wilkins's explorations was his work as a naturalist. He made collections in Australia ; and he joined Shackleton on the *Quest*, for example, as a collector of natural history specimens. Wilkins was also in the Antarctic with

J. L. Cope in 1921 along with T. W. Bagshaw and M. C. Lester.

One of his most spectacular proposals, however, was his putting forward the idea of taking a submarine under the arctic pack-ice, and by the effort which he made with Lincoln Ellsworth in 1931 he was thus anticipating the successful voyages made by a later *Nautilus* in 1958.

One of Wilkins's earlier associations with Lincoln Ellsworth had led to an important flight across a sector of Antarctica in December 1928. On this occasion a message reached Britain from Wilkins, who was on board ship, that Ellsworth had got into difficulties after reaching the edge of the Ross Barrier together with his pilot, Ben Eielson. This led the British Colonial Office to arrange that the *William Scoresby* should be diverted at short notice to the Antarctic, and Ellsworth and Eielson were picked up without difficulty.

Wilkins, on these flights in December 1928, had stated that Graham Land was insular. This led to much confusion at the time and attempts to identify places in Graham Land such as Stefansson Strait and Crane Channel. The matter was not cleared up until the Rymill Expedition began surveys in 1934. Wilkins had, in fact, regarded as straits what in reality were glaciers. At the time, however, Wilkins's claims to have discovered 'Hearst Land' and 'Stefansson Strait' were a source of controversy.

Hubert Wilkins was one of the earliest explorers of the air age, and his picturesque figure with his short, trim beard made him well known and popular in the United States, where he had made his home.

J. M. Wordie

Prof. Florence A. Mockeridge

Florence Annie Mockeridge, emeritus professor of botany in the University College of Swansea, died on December 18 at the age of sixty-nine.

Florence Mockeridge studied first at Woolwich Polytechnic (Penfold gold medallist) and then at King's College, London, as a Merchant Taylor's Company Scholar. She graduated with first-class honours in the Pass B.Sc. in 1909 and again in the Honours B.Sc. in 1910 and was awarded the Carter Gold Medal of King's College. During 1911–17 she undertook research with Prof. W. B. Bottomley, first as a Layton Research Student and later with grants from the Board of Agriculture and Fisheries. During this period she was engaged upon pioneer studies on nitrogen fixation by *Azotobacter* and on the growth-promoting substances ('auximones') of natural manures. Her published researches in this field led, in 1917, to the award of the D.Sc. (London). During 1917–22 she was successively demonstrator and University lecturer in botany at King's College and, continuing her researches, demonstrated the presence in natural manures of nucleic acid degradation products, including the purine bases, and examined their growth-promoting activities.

In 1922, Dr. Mockeridge was appointed independent lecturer in botany in charge of the Department of Biology of the newly established University College of Swansea. Here, in improvized accommodation and with a very small staff, she built up, over a period of thirty-two years, the reputation of the honours degree in botany and directed the work of a succession of research students. Her outstanding ability as a teacher and her scientific achievements in the face of inadequate facilities and often indifferent health were recognized by her election in 1936 as the first professor of botany in the College. She long pressed for the establishment of separate Departments of Botany and Zoology, and when, shortly before her retirement in 1954, this was to become possible by the decision to erect a new Natural Sciences Building (*Nature*, 179, 124; 1957) she planned the new facilities with great care and wisdom in full knowledge that their use would be for her successors.

Prof. Mockeridge also played a big part in the development of the University College, being dean of the faculty of science during 1933–35 and again during 1941–43, vice-principal during 1949–51 and, for many years, treasurer of the Student's Representative Council. She took a deep personal interest in the welfare and continuing progress of her students, whose affection and respect for her were recently expressed by their presentation to the Department of Botany of her portrait in oils.

She was always much sought after as a lecturer all over South Wales. For many years she was editor of the *Proceedings of the Swansea Field Naturalists' Society*. On her retirement she became chairman of the Science Committee of the National Museum of Wales and a member of the Glantawe Hospitals Management Committee.

H. E. Street

Sir Ralph Pearson, C.I.E.

Ralph Sneyd Pearson, who died on December 8, aged eighty-four, was educated at the Royal Indian Engineering College, Coopers Hill, and joined the Indian Forest Service in 1898.

After service as a territorial forest officer in the Bombay province, he was posted to the Forest Research Institute, Dehra Dun, to take charge of the recently formed Economic Branch in 1909. Until 1920 he had to work largely single-handed, devoting special attention to the adoption by the railways of antiseptically treated sleepers to relieve the heavy demands on the supply of naturally durable timbers. He also surveyed the possibility of using bamboo for paper-making on a commercial scale.

In 1920 the Economic Branch was much enlarged by the formation of several sections dealing with special aspects of the utilization of forest products, and Pearson was sent to Canada and the United States to recruit specialists to take charge of some of them. It was then that the results of the work he had done before and during the First World War began to gain the general acceptance they have since received with great benefit to Indian industry.

In 1925 he retired from the Indian Forest Service and returned to Britain, where he was appointed director of the new Forest Products Research Laboratory (Department of Scientific and Industrial Research), which he built up very much on the lines of his branch at Dehra Dun. There he remained until 1933, when he had to retire for reasons of health.

He was made C.I.E. in 1920 and was knighted in 1933; he received the honorary degree of LL.D. of the University of St. Andrews.

The author of several monographs on various forest products, his chief work was "The Commercial Timbers of India", written in collaboration with the late H. R. Brown, of the New York State College of Forestry. He was a good shot and a very keen cricketer who was always very popular with his staff.

He married Constance Ommaney, who died in 1938, and he is survived by two sons and a daughter.

W. A. Robertson

NEWS and VIEWS

Physical Biochemistry at Canberra : Prof. A. G. Ogston, F.R.S.

DR. A. G. OGSTON has been appointed to the chair of physical biochemistry in the Australian National University at Canberra. This is a new establishment, and his Department will be housed in the John Curtin Institute for Medical Research, where Prof. A. H. Ennor holds the chair of biochemistry. Dr. Ogston took a first-class degree in chemistry at Oxford in 1933. Later, in 1938, he took a degree in physiology and was appointed Oliver Gatty Fellow and Tutor in Biological Sciences at Balliol College. In addition to his college fellowship he holds the appointment of reader in biochemistry in the University of Oxford. His teaching and research have been characterized by an unusually clear understanding of both the physical and biological approaches and their relation to one another. His recent work has been concerned mainly with the properties of hyaluronic acid and its isolation from synovial fluid. Since 1955 he has been chairman of the editorial board of the *Biochemical Journal*. The formation of a department devoted to physical biochemistry in Canberra will be important, not only for the work it produces but also for the stimulus it provides ; the Australian National University is to be congratulated in attracting a scientist of such distinction. Dr. Ogston will take up the appointment in 1960.

Chemistry at Edinburgh : Prof. J. P. Kendall, F.R.S.

JAMES PICKERING KENDALL, who is retiring from the chair of chemistry in the University of Edinburgh at the end of the present academic year, succeeded Sir James Walker in that chair in 1928, the appointment following an extensive experience of university teaching, research and administration as professor of chemistry in Columbia University, New York (1913–26), and in New York University (1926–28). His graduation in Edinburgh as M.A., B.Sc. in 1910 was followed by his association with Arrhenius and other continental workers in the earlier work on solutions, leading to his active research interest in general solution chemistry, with particular reference to ionic migration. The course of this work was accompanied by the publication of an extensive series of articles and text-books, particularly the Smith–Kendall series of college chemistries, and including "At Home among the Atoms" (1929), "Breathe Freely" (1938), "Young Chemists and Great Discoveries" (1939), and "Humphry Davy" (1954). He was elected a Fellow of the Royal Society in 1927.

During the past thirty years Prof. Kendall has taken a full share of Senatus and Faculty business—he is at present Dean of the Faculty of Science—and has served as a member of the University Court and of many of its committees. His tenure of the chair has been marked by many changes in the Department of Chemistry, particularly during the post-war period. These have included the institution of the Forbes chair of organic chemistry, to which Prof. E. L. Hirst was appointed in 1947, the enlargement and rebuilding of the Department and extensive developments in teaching and research. Prof. Kendall has for many years taken a great interest in the work of the Royal Society of Edinburgh, being in turn member of Council, secretary for meetings and general secretary, a post he occupied during 1939–49. During 1949–54 he served with distinction as president of the Society.

Dr. T. L. Cottrell

DR. TOM LEADBETTER COTTRELL, who has been appointed to succeed Prof. James Kendall, received his early education at George Watson's Boys' College, Edinburgh. After entering the University of Edinburgh, he specialized in chemistry and graduated B.Sc. in 1943 with first-class honours. He then took a post in the Research Department of the Explosives Division of Imperial Chemical Industries, Ltd., where he developed his interest in physical chemistry. In 1946 he was seconded for special work in the Physical Chemistry Laboratory of the University of Oxford. Shortly after his return to Ardeer he was appointed head of the Physical Chemistry Research Section of the Nobel Division of Imperial Chemical Industries, Ltd. His contributions to the solution of fundamental problems in physical chemistry, with particular reference to chemical kinetics, thermochemistry and intermolecular forces, were of such outstanding merit that he was awarded in 1952 the Meldola Medal of the Royal Institute of Chemistry. Two years later he published a book on "The Strengths of Chemical Bonds", the second edition of which was called for after an interval of only four years. In 1958 he was awarded the D.Sc. degree of the University of Edinburgh for his achievements in physical chemistry. After a wide experience of both fundamental and applied research work at Ardeer, Dr. Cottrell was transferred in 1958 to the directorate staff of Imperial Chemical Industries, Ltd., at its London headquarters, where he acted as personal assistant to Sir Ewart Smith, deputy chairman of the Company. In returning to Edinburgh at the age of thirty-five, Dr. Cottrell will become a professor in the department in which his father previously held the post of lecturer in technical chemistry.

Royal Astronomical Society Awards

THE Royal Astronomical Society has recently made the following awards : the Gold Medal of the Society to Dr. R. A. Lyttleton, lecturer in mathematics in the University of Cambridge, for his outstanding contributions to many branches of theoretical astronomy, in particular to the problems of the stability of rotating fluid masses, of the constitution of the stars and stellar evolution, and of the origin and peculiarities of the solar system ; and the Eddington Medal to Dr. J. S. Hey, of the Royal Radar Establishment, Malvern, for his outstanding discoveries concerning radio emission from the active Sun, radio reflexions from meteors, and discrete sources of cosmic radio emission.

Gold Medals of the Institut Francais des Combustibles et de l'Energie

GOLD medals, designed to recognize outstanding achievement in the field of utilization of fuel and power, were recently presented in Paris to six fuel technologists of international reputation. The medals were a new foundation of the Institut Français des

Combustibles et de l'Énergie, and the presentations were made by M. Ramonet, the then Minister of Industry and Commerce. The recipients were Dr. D. T. A. Townend, director-general of the British Coal Utilization Research Association; Prof. W. H. McAdams, Massachusetts Institute of Technology; M. G. Darrieus and Prof. G. Ribaud, members of the Academy of Sciences, Paris; Dr. F. Münzinger, German Federal Republic; and Signor F. Squassi, presidente della Sezione Latium dell'Associazione Termotecnica Italiana.

A Large Sunspot Group

THE large sunspot group which has recently attracted some attention appeared around the Sun's limb in heliographic latitude 12° N. on January 4. It was carried across the disk by the Sun's rotation about its own axis, and disappears at the western limb on January 17. A close bipolar structure, the group has somewhat diminished in area since January 8, when its area was 3,000 millionths of the Sun's visible hemisphere. It is, however, the largest group observed since May 1951 and, consequently, of the present sunspot cycle. Although there has been an unprecedented number of spots during the recent peak activity, no group has been observed approaching in size that seen in April 1947, the maximum area of which reached 6,100 millionths of the Sun's visible hemisphere and was the largest recorded since the Greenwich observations began in 1874. Adverse weather conditions at Herstmonceux have prevented continuous watch on this group, but so far (until January 11) no associated flare activity has been observed.

Central Advisory Water Committee

THE Central Advisory Water Committee recently held its fourth meeting in London at the Ministry of Housing and Local Government, under the chairmanship of the Minister, Mr. Henry Brooke, when it received and adopted reports from two sub-committees set up in 1955 to inquire, respectively, into the growing demand for water and into the collection of information about water resources. Both reports will be published shortly.

The Committee requested the sub-committee on the demand for water to undertake a further inquiry, with extended terms of reference as follows: "In connexion with their investigations into the extent to which demands for water are increasing and the problems involved in meeting those demands, to inquire into the extent of uncontrolled abstractions of surface water for agriculture, especially irrigation, for industry and for other purposes, and into the effect of such abstractions on the quantity and quality of surface water available for all purposes; to consider whether powers are needed to control such abstractions in general or in particular; and to make recommendations". Prof. J. Proudman was appointed chairman of the sub-committee in succession to Alderman Yates, who has resigned from the chairmanship owing to pressure of other work.

Zoological Society of London: Young Zoologists Club

ALTHOUGH the Zoological Society of London has been in existence for more than a hundred years, it has never had a junior section through which the great amount of scientific knowledge at its disposal could be made available to school-children. About a year ago it instituted, with the co-operation of the educational authorities of the Greater London area, regular lecture-demonstrations for school-children. The Society is now launching a Young Zoologists Club (XYZ Club) for children between the ages of eleven and eighteen. The Club will be based on the London Zoo. For 10*s*. a year (there are, as well, reduced subscription rates for schools, clubs and natural history societies) the membership includes the Club badge, free admission tickets (to the London Zoo, including the Aquarium and Children's Zoo, and Whipsnade Park), competitions with substantial cash prizes, meetings, an Information Bureau and, above all, the *Zoo Magazine*, which for the present is being published three times a year. Further information can be obtained from XYZ Club, The London Zoo, Regent's Park, London, N.W.1.

Geochemistry

As a means of making available to all interested individuals some of the current Russian research in geochemistry, the Geochemical Society of the United States has undertaken to publish an English translation of the Russian journal *Geokhimiya*, published by the Academy of Sciences of the U.S.S.R. The first number of this translation has now appeared (*Geochemistry*, No. 1, 1958. (A translation of the journal of the Academy of Sciences, U.S.S.R.) Pp. 1–130. Subscription (for eight issues) 20 dollars a year. Ann Arbor, Michigan: Geochemical Society, Prof. E. Wm. Heinrich, Mineralogical Laboratory, The University, 1958). It contains research papers dealing with the ionium method of determining the age of marine sediments, the formation of free hydrogen in the Earth's crust, X-ray investigations of natural oxides of uranium, paragenesis in boron-bearing magnesium skarns, the evolution of rocks during progressive metamorphism, the distribution of cobalt, nickel and copper in hydrothermally altered rocks, experimental studies of the oxidation of cobalt and nickel arsenides in solutions containing oxygen and carbonic acid, rhenium in molybdenites, the zirconium/hafnium ratio in zircons, and a contribution to the geochemistry of titanium in intrusive processes of granitic series. The translation concludes with a brief description of the recent International Conference on Interplanetary Science.

Symposium on Peptide Synthesis

AN International Symposium was held in Prague during September 8–15, when chemists from many countries in Europe met, at the invitation of the Czechoslovak Academy of Science, to discuss the synthesis of peptides. The primary object of the symposium was to exchange experience in this field rather than to communicate new work (although several of the contributions included unpublished work), and as a basis for each section of the discussion reviews were contributed by Prof. T. Wieland (Frankfurt) on peptide bond formation based on carboxyl activation; Prof. S. Goldschmidt (Technische Hochschule, Munich) on peptide bond formation based on amino-group activation; Dr. G. T. Young (Oxford) on racemization in peptide synthesis; Dr. E. Wünsch (Max Planck Institut, Munich) on amino-group protection; Prof. E. Taschner (Danzig) on carboxyl group protection; Dr. J. Rudinger (Prague) on peptides of the diamino and dicarboxylic acids; Prof. M. Brenner (Basle) on peptides of the hydroxy-amino-acids; Dr. Young on peptides containing cysteine; Prof. M. M. Shemyakin (Moscow) on peptides of α-substituted α-amino-acids; and Dr. M. Rothe (Berlin) on the synthesis of cyclic peptides. A paper on the synthesis of optically active peptides from racemic amino-esters, by Prof. M. M. Botvinik (Moscow), was read in her absence. The proceedings, with the discussion, are to be published in a special issue of the *Collection of Czechoslovak Chemical Communications*. It was generally agreed that the meeting had been most rewarding, and that an attempt should be made to gather regularly in this fashion.

World Low Air Temperature Record

THE world low air temperature record of – 102·1° F. at the South Pole on September 18, 1957 (*Nature*, 181, 1109; 1958), was exceeded in the polar night of 1958 at the Russian International Geophysical Year Antarctic stations Sovetskaya (78° 24′ S., 87° 35′ E., elevation about 3,700 m.) and Vostok (78° 27′ S., 106° 52′ E., about 3,500 m.) The Sovetskaya station recorded – 86·7° C. (– 124·1° F.) between 1900 and 2000 L.M.T. on August 9. The measurement was made with a distant-reading electrical-resistance thermometer of known correction. The temperature is stated to have been lower immediately afterwards but there was no calibration for the thermometer. Other readings nearly as low at these stations were:

Vostok:	– 80·7° C.	(– 113·3° F.)	on June 15
	– 85·8° C.	(– 122·4° F.)	on August 8
Sovetskaya:	– 81° C.	(– 113·8° F.)	on June 19
	– 83° C.	(– 117·4° F.)	on June 25

The extremes in June occurred in periods of light winds and clear or nearly clear sky, which is the weather most favourable for very low temperatures. No information is available about the weather at the time of the August readings. The values were stated in reports from the American meteorologist, Mr. Morton Rubin, at the Russian base at Mirny, published in the *Monthly Weather Review* of the U.S. Weather Bureau.

Oystercatchers and Mussels

R. E. DRINNAN, of the Fisheries Research Board of Canada and formerly of the Fisheries Experiment Station, Conway, has described the feeding of the oystercatcher (*Haematopus ostralegus*) on the edible mussel (*Mytilus edulis*) in the estuary of the River Conway, Caernarvonshire, during the winter 1955–56 (Ministry of Agriculture, Fisheries and Food Fishery Investigation, Ser. 2, 22, No. 4). Feeding was studied on the mussel beds at the mouth of the River (Morfa) and in an area higher up the estuary above the suspension bridge (Pensarn). The oystercatcher populations of these areas are discrete. The birds are present between August and late March and are probably British breeding birds. Feeding follows the tidal cycle, continuing throughout the period when mussels are uncovered, high water periods being spent in non-feeding roosting flocks. This cycle continues during darkness. Quantitative data on food intake for the daylight feeding period show that each bird eats about its own weight of wet mussels a day. No precise measure of the effect of oystercatcher predation on the mussel population was made; but, at the Morfa, population samples through the winter showed the steady removal of the larger size groups by the birds. The present work is compared with previous results obtained by Dewar in the Firth of Forth and many divergences noted. These can all be ascribed to differences in feeding behaviour of the birds in the two studies.

Harwell Reactor School Courses

A SECOND course on the Control and Instrumentation of Reactors will be given at the Harwell Reactor School, Berkshire, during July 7–17, and will be open to British and overseas students. The topics to be treated will include: revision of elementary reactor kinetics, control and instrumentation; automatic control of reactors and nuclear power plants; application of computers; reactor transfer functions and function analysers; neutron flux scanning; radiation detectors and their siting in reactors; reactor safety circuits; conventional instrumentation; use of transistors in reactor instrumentation; burst slug detection; spatial instabilities in reactors; and data-reduction problems on large reactors. In addition to the lectures, there will be visits to zero-energy and high-flux research reactors and other relevant parts of the Atomic Energy Research Establishment. The fee for the course will be 50 guineas, exclusive of accommodation, and application forms, available from the Reactor School, must be returned by May 7 to the Principal.

United States Atomic Energy Commission Training Courses

THE U.S. Atomic Energy Commission has established a training programme at the Shippingport Atomic Power Station for supervisory personnel of domestic and foreign organizations engaged in or planning the design, construction or operation of nuclear power plants. The training programme is being conducted at the Shippingport Atomic Power Station, Pa., a joint project of the Commission and the Duquesne Light Co., because it is the only large-scale nuclear electric power plant at present in operation in the United States. It will be conducted by the Duquesne Light Co. for the Commission, and will enrol twenty-five participants every three months for a six-month training course, which will include lectures and practical plant work. The courses, the first of which started on January 5, are designed to acquaint the participants with the operation of the Shippingport plant and to provide operational training within the plant. The tuition charge is 2,000 dollars to cover associated operating costs.

University News: Birmingham

THE Council of the University of Birmingham has received from the firm of Joseph Lucas, Ltd., a gift of £100,000, to be used for building a hall of residence for graduate students in engineering.

The title of reader in experimental pathology has been conferred on Dr. K. W. Walton, senior lecturer in experimental pathology, and that of reader in mathematical economics on Dr. F. H. Hahn, senior lecturer in economics. The following appointments have also been made: Dr. D. B. Idle, to be lecturer in botany; Dr. B. John, to be lecturer in cytology in the Department of Genetics; Dr. R. G. O. Kekwick, to be lecturer in malting and brewing and applied biochemistry.

Leeds

MR. J. TRENAMAN has been appointed to the Granada Television Research Fellowship, endowed by Granada TV Network, Ltd., in the University of Leeds, for a minimum period of five years, with provision for the necessary staff and services. The purpose of the Fellowship is to undertake research into the impact of television over as wide an area of inquiry as practicable in the fields of entertainment, politics, information and public affairs—and into its influence on public tastes, habits and outlook. Mr. Trenaman read English at King's College, London, and later graduated B.Litt. in the University of Oxford. In 1945 he was appointed head of analysis in the B.B.C. Audience Research Department, and in 1948 became research officer to the B.B.C. Further Education Experiment exploring the use of broadcasting as a medium of education. He has since held the post of further education liaison officer to the B.B.C.

"Fuel and Power in British Industry"

MR. A. M. WANDLESS, of the Scientific Department, National Coal Board, writes: "In the article under this title which appeared in *Nature* of December 20, I am reported as having stated in my address to the Manchester Joint Research Council's Symposium on Fuel and Power that the workable reserves of coal in Britain are of the order of 1,000 million tons. This, of course, is an absurdly low figure. In dealing with the difficult and necessarily uncertain business of attempting to predict workable or economic reserves of coal, I said that figures as low as 44,000 million tons (that is, 200 years life at the present rate of extraction) had been computed, but that this estimate was almost certainly too low. I suggested an upper ceiling of 100,000 million tons, but I pointed out that it all depends how much we are going to need coal in the future, and what we are prepared to pay for it. There is probably something of the order of 170,000 million tons lying in the ground in seams more than 1 ft. in thickness".

Birds and Mammals of Canada

REFERENCE was made in *Nature* of November 15, p. 1347, to two recent publications from the National Museum of Canada, namely, "Quelques Oiseaux du Canada" and "Canadian Mammals". We are informed that the first of these is available also in English under the title "Some Canadian Birds", this being the original version. The price is the same as that of the French edition, 35 cents.

Announcements

AN honorary degree of doctor of technical science was conferred on Sir John Cockcroft by the Technical University of Delft on January 10.

PROF. J. M. YOFFEY, professor of anatomy in the University of Bristol, has been appointed Knight first class of the Order of the Dannebrog for his services to the Medical Schools of the Universities of Copenhagen and Aarhus.

MR. GUSTAVUS GREEN, known for his work on the design and development of the early Green aero-engines, has been made an honorary companion of the Royal Aeronautical Society; Mr. Green was born in 1865 and designed the 60-h.p. engine used in a Short No. 2 biplane flown in 1909.

SIR RUSSELL BRAIN, president during 1950–57 of the Royal College of Physicians, will give the Eddington Memorial Lecture for 1959 in Cambridge, at the Arts School Lecture Theatre, Bene't Street, on February 24, at 5 p.m. The title of the lecture will be "Science, Philosophy and Religion".

THE Czechoslovakian Academy of Sciences and the Purkyne Medical Society have arranged a symposium on antibiotics, to be held in Prague during May 18–23. The symposium will be divided into three sections on: problems of the biosynthesis of antibiotics; the scientific pathophysiological basis of antibiotic therapy; and the problems of fermentation engineering and the non-medical uses of antibiotics. Summaries of papers covering new and unpublished results, to be read in English, German, Russian or Czech, should be received by the secretary, Dr. M. Hermansky, Antibiotics Research Institute, Rostoky, near Prague, not later than February 15.

THE third conference on Electronic Digital Computers and their Industrial Applications will be held in the Department of Mathematics, College of Technology, Birmingham, on February 25, when members of the English Electric Co. will deliver talks on the installation, operation and maintenance of digital computers; programming strategy and techniques, including automatic programming; engineering and scientific problems; the use of a computer system in commercial organization; and the mortgage problem. Applications can be made to the Registrar, College of Technology, Gosta Green, Birmingham 4.

AN international symposium under the auspices of the Centro per la Vaccinazione Antitubercolare of the Istituto d'Igiene dell'Universita di Pisa, devoted to the topic of vaccination against tuberculosis with non-living vaccines, will be held in Florence during April 5–7. The organization of the meeting has been undertaken by the director of the Centre, Prof. Giulio Buonomini, from whom further information can be obtained. The symposium is intended to provide an opportunity for the exchange of information, experiences and ideas by investigators actively engaged in attempts to produce a safe and effective non-living vaccine against tuberculosis. To assure a maximum degree of informality and freedom of discussion, participation in the symposium has been limited to about twenty invited workers.

THE National Academy of Sciences with the joint sponsorship of the National Science Foundation, the Office of Naval Research and the Air Force Office of Scientific Research has arranged an international seminar on "The Atomic Mechanisms of Fracture", to be held at the New Ocean House, Swampscott, Massachusetts, during April 12–14. The central theme of the conference is the basic atomic mechanism by which fracture occurs in metals, ceramics and polymers; emphasis is placed on fundamental studies of the basic mechanisms of cleavage and of ductile, fatigue and high-temperature fractures. The programme will consist of a series of invited papers, which will be circulated in advance. Further information and forms of application can be obtained from Prof. B. L. Averbach, chairman, or Dr. D. K. Felbeck, secretary, Conference on Fracture, National Academy of Sciences, 2101 Constitution Avenue, Washington 25, D.C.

MR. W. A. FERGUSON, who has been appointed secretary of the British Museum (Natural History), is at present in the Director's office, British Museum (Bloomsbury), and not at South Kensington, as stated in *Nature* of January 3, p. 18.

SCIENTIFIC RESEARCH IN AUSTRALIA

THE ninth annual report of the Commonwealth of Australia Scientific and Industrial Research Organization* covers the year 1956–57, in which expenditure was £6,575,255. Of this, £935,830 was expended on investigations financed from the Wool Research Trust Account, which under the new Wool Research Act should now have an income of about £1,700,000. Some new arrangements were made with the universities, including the establishment with the New England University, Armidale, of a laboratory to be used jointly by the University's Faculty of Rural Science and the Organization's Regional Pastoral Laboratory, Armidale; and, with the University of Melbourne, of a joint Engineering Research Station for the study of soil mechanics. Two main research projects relating to water supplies have developed with great promise. The Division of Radiophysics full-scale field trial of artificial rain-making over the Snowy Mountains over two winters promises an increase in rainfall over the target area, and the Mansfield process using cetyl alcohol, developed in the Division of Industrial Chemistry, is now finding application in reducing evaporation from small farm dams and, in modified form, is effective in large reservoirs.

Special reference is made to the completion by the Cattle Tick Research Review Committee of its survey of research within its field. The Committee recommended completion of the ecological background and field tests of pasturing and strategic dipping; studies of tick fevers to assess the consequences of efficient control of ticks; toxicological investigations, especially completion of the work on DDT; and the study of resistance to tick in cattle. The investigations to establish the genetic factors which enable cattle to withstand tropical conditions have indicated that the rate of sweating of zebu cross-breds is not necessarily higher than the average of British breeds, and their ability to withstand heat is thus related to other factors.

In soils research special effort has been directed to the preparation of a new soils map of Australia, and it is hoped to complete the whole project by 1960. In soil chemistry a start has been made on the study of the geochemistry of the three main groups of soils developed on dolerite in Tasmania. In soil physics an equation has been derived for the relation between permeability and the size-distribution of the pores in isotropic porous material, and recently the Division has included soil-stabilization projects in its programme.

The development of the Tobacco Research Institute at Mareeba has progressed and work commenced on tobacco culture, while at Canberra blue-mould disease is being investigated. The investigations into the possibility of establishing safflower as an oil crop in Australia have been concluded. Varieties giving economic yields of oil of high quality have been developed, and the returns per acre were equal to those from wheat in areas suited to the crop. Broad-scale ecological surveys were carried out in the under-developed arid and semi-arid regions of the continent to assess their potential land-use and to investigate problems of agricultural and pastoral development. In work with skeleton weed in cereal crops, selective weed-killers applied before sowing wheat or in the early seedling stage of oats have given marked increases in the yield of grain, due to an increase in the nitrogen available to the crop, while improvement programmes with cattle pastures have enabled cattle in the spear grass region to be marketed one year earlier than is possible from native pastures; in the coastal lowlands sheep and cattle can now be wholly maintained on sown pastures; and in the brigalow country introduced grass and legume species have given highly promising results. Indolyl-3-acetic acid increased the growth of both the veins and petioles of leaves according to a similar pattern, and work has commenced on the recognition of factors which may control leaf-blade (laminar) growth. A study has been made of the ultra-violet spectra and acid-strength of some chlorinated phenoxyacetic acids and their phosphonous and phosphonic acid analogues. Reconnaissance of the east Australian rain-forests was complete, while work in the Murrumbidgee Irrigation Area indicated that impedance to the flow of water in farm ditches due to inflorescences of *Paspalum dilatatum* can be removed by spraying with maleic hydrazide.

Biophysical research supported at the University of Tasmania includes the development of micro-electrode techniques to measure potential differences between points in the cytoplasm of large plant cells such as *Nitella* and *Chara*, further studies of the steady electric field pattern around plant roots growing in solutions of various ionic compositions and concentrations, and studies of the nature of transient changes in the electric field of bean roots following stimulation.

The Plant Fibre Section is developing methods of chemical analysis for examining the changes associated with the conservation and storage of fodder both as hay and silage, and the research programme of the Division of Animal Health and Husbandry continued to place emphasis on contagious pleuro-pneumonia of cattle, infectious forms of infertility and worm parasites, besides the tick research already noted. Good progress is reported with the major production problems with cattle, but—with the greatly reduced significance of the sheep blowfly and other external parasites of sheep through increased knowledge of diseases of sheep and the advent of modern insecticides—research on sheep has been greatly reduced. Nevertheless, foot rot and foot abscess, mycotic dermatitis and worm parasites continue to occupy an important place in the Division's research programme.

Insect ecology and physiology have continued to be the two principal research themes of the Division of Entomology, but besides the developing emphasis on cattle-tick research, the biological control of weeds and the Queensland fruit-fly are increasingly important. Work on the biological control of Noogoora burr was initiated, and the nature of insect resistance to insecticides was further studied in several strains of house-fly. The Wildlife Survey Section concluded its investigations of the marsupials of New South Wales and continued its work on rabbit myxomatosis, while the Division of Fisheries and Oceanography is investigating the interaction between sunlight and chlorophyll in marine plants to enable carbon dioxide in the water to be converted into plant and animal tissue. The Division of Food Preservation and Transport continued to investigate the reaction products in browned freeze-dried apricots and peaches and completed the identification of the cationic constituents, and in a series of studies parallel with those on the 'tenderizing' of beef examined the breakdown of nucleotides in the muscle tissue. Much effort was made to improve methods for killing fruit-fly in harvested fruits, and studies designed to determine the effect of different amounts of initial oxygen in the head space of highly corrosive canned products were continued with test packs of blackcurrants in syrup.

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* Commonwealth of Australia. Ninth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year 1956–57. Pp. 179. (Canberra: Government Printer, 1958.) 10*s*. 6*d*.

An extensive programme of research has been undertaken to improve the use of wool as a textile fibre, using increased knowledge and understanding of the complex structure of the wool fibre and its physical and chemical properties to improve it as a textile fibre. Much attention has been directed to simplifying the conventional techniques of worsted processing, and investigations continued on the treatment of woven fabrics with casein, with the object of devising an inexpensive method of shrink-proofing using aqueous solutions. Besides studies on the extension of wool fibres and their setting at new lengths, either temporarily or permanently, research on the degradation of cellulose by fungal enzymes has been diverted from the problem of protecting tent canvas against attack by moulds and linked with research on the digestibility of pasture plants by sheep. The study of the constituents of wool-wax is now concerned chiefly with the long-chain acids of the wax and with lanosterol.

Besides the Mansfield process already noted, an outstanding success of the work of the Division of Industrial Chemistry has been the zirconium–hafnium separation process resulting from its study of the chemistry of Australia's beach sands. Work on the industrial extraction of germanium from the flue dusts of coal-burning power stations continued. Crystallographic studies were directed to the chalcogenide systems of thorium with sulphur, selenium and tellurium. A novel method was evolved of increasing the resistance of concrete products to attack by sulphate solutions. Work was commenced on some aspects of fighting bush fires, the nucleation of clouds, and the separation of the components of tar from the Lurgi process for gasifying brown coal. The theoretical and experimental study of defects in crystals and of their implications in determining the physical and chemical properties of solids continued, as well as the search for alkaloids of possible pharmaceutical value from the native flora, a study of root exudates and their possible significance to agriculture, and the examination of plants known or suspected to be poisonous to live-stock. Considerable progress is reported in basic studies of the chemical reactions of importance in the pressure gasification of brown coal.

The Division of Tribophysics reports major advances in the knowledge of distortions in metals produced by plastic deformation and of topology and reactivity of metal surfaces, and it appears that grain-size is important in controlling both the plastic properties of copper and its annealing characteristics. Demands on the services of the Division of Metrology are increasing, and the electrolytic condensation hygrometer developed by the Division of Physics has fulfilled its early promise, and studies of the basic physics of the crystal surface were made. Research work at very low temperatures was extended to include studies of paramagnetic resonance, and work is in progress to determine the gyromagnetic ratio of the proton. In dielectrics research the emphasis was chiefly on the effect of crystal imperfections on the dielectric properties of solids, but some work continued on liquids, and a theoretical investigation was made of problems related to superconductivity in metals.

The Division of Radiophysics is investigating the basic physical properties of semiconducting materials, and the Organization is undertaking basic studies of the physics of the atmosphere with the view of obtaining a more fundamental knowledge of the weather and the processes which control it. These include further intensive field work in the 'cool change' project, in addition to the Snowy Mountains project already noted, and towards the end of June 1957 emergency operations were commenced in an attempt to induce the maximum possible precipitation from any suitable cloud formations over general areas of the eastern States where drought conditions were beginning to be experienced. In radio astronomy, two large Mills cross-aerials were completed for the study of radio waves from beyond the solar system, and a long programme of observations of the southern part of the Milky Way at a wave-length of 21 cm. yielded interesting results on the general structure of the Galaxy. A new crossed-grating interferometer, designed for high-resolution observations of the Sun, was completed and is in operation. Lists of staff and personnel of the council and committees of the Organization and of published papers are included in the report.

FINANCE OF SCIENTIFIC RESEARCH IN BRITAIN

IN opening an adjournment debate in the House of Commons on December 18 on Government aid to science in Britain, Mr. F. Willey urged the need for more wholehearted support for fundamental research and a bolder approach to science such as characterizes the National Science Foundation in the United States. He suggested that the main responsibility for fundamental research must rest with the Government, but that much other scientific research requires Government assistance in some form and that industry must be persuaded to devote more resources to research. Referring more particularly to the Department of Scientific and Industrial Research, he suggested that the appointment of a full-time chairman to the Council should be considered, and that the status and authority of the Department should be increased. Mr. Willey was disturbed about the disbandment of the Microbiological Group at the National Chemical Laboratory. Nevertheless, he paid a tribute to the work of the present Lord President of the Council, which was endorsed by Mr. R. Fort, who, while in general supporting Mr. Willey's views, argued that fundamental research should properly be the responsibility of the universities. Like Mr. Willey, he echoed some criticism of the British national organization of research which has been recently voiced in *Nature*, but thought that the four research councils provided a good mechanism for determining research priorities and that this pattern could be more widely applied.

In his reply for the Government, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, after reviewing briefly the general pattern of Government support for civil science, pointed out that in the past two years the expenditure of the Department of Scientific and Industrial Research has increased by 23 per cent, of the Medical Research Council by 34 per cent, of the Agricultural Research Council by 20 per cent, and of the Nature Conservancy by 25 per cent. He then announced that the Government has decided to repeat the experiment of financing the Department of Scientific and Industrial Research on a five-year basis. In the first quinquennium ending on March 31, 1959, total expenditure would be about £36 million; for the next quinquennium a total of £61 million is envisaged, reaching £14 million for 1967–68, excluding the contribution to the European Organization for Nuclear Research. Paying tribute to the work of the research associations, Mr. Nicholls said that the thirty-nine research associations and ten smaller organizations in the scheme employ a staff of 4,500, of whom 1,500 are of graduate status, and the 20,000 member firms cover about 50 per cent of manufacturing industry. To their expenditure of about £7 million in 1957–58 the Department of Scientific and Industrial Research contributed about £1·75 million in grants, and for the next quinquennium this will be increased to more than £2 million.

In regard to the universities, Mr. Nicholls agreed that we should look to them mainly for fundamental research and he stressed the value of the increase of postgraduate awards by about 10 per cent in the next five years. By 1963–64, 3,800 students will be receiving grants for training and research from the Department of Scientific and Industrial Research compared with 1,900 this year, and the amount available for research in universities and similar institutions will also be increased three-fold or four-fold in the next five years. In the current year university building projects to the value of £12 million are being started; for the years 1960–63 this will rise to £15 million a year, and technical college building projects to the value of £15 million a year had been in hand since the end of 1956. He had every reason to believe that the target output of 20,000 scientists and engineers a year set for the late 1960's will be achieved.

In conclusion, Mr. Nicholls said that he understood the decision of the Council for Scientific and Industrial Research with regard to the Microbiological Group at the National Chemical Laboratory was taken entirely on scientific merits and without any Ministerial intervention, which would have been entirely contrary to the spirit of the Act. The Lord President was satisfied that the Council had given extremely careful thought to the matter before giving its decision. Mr. John Hynd later referred to the outstanding £130,000 in the capital cost of constructing the Jodrell Bank radio telescope. Mr. Nicholls, in reply, pointed out that the House itself had welcomed the assurance that no voted money should be spent on covering this outstanding item. Later, in a written answer, he added that the Department of Scientific and Industrial Research had already provided £350,000 towards the cost of construction, and had funds at its disposal for financing research of special timeliness and promise. Any applications from the University of Manchester for grants for future research involving the use of the radio telescope would be considered on their merits, and one such grant of £15,200 had recently been offered.

A RADAR SIMULATOR SYSTEM

DURING the Second World War the training of Royal Air Force radar operators was greatly facilitated by the use of apparatus which enabled aircraft echoes to be simulated on the screen of the cathode-ray oscillograph in the radar receiver. Much ingenuity was applied to devising techniques whereby such artificial echoes could be produced and applied to the radar in such a way as to simulate the movement of a real target. By the use of the training equipment which resulted, the need to produce real echoes by flying aircraft was obviated, with consequent savings in fuel, wear and tear of aircraft and elimination of the difficulties of organization and administration.

From these war-time beginnings subsequent development of radar trainers has been considerable, as was shown by the demonstration recently given at the Farnborough works of Solartron Electronic Group, Ltd., of an elaborate installation for simulating air defence exercises and providing realistic instruction in the radar control of the interception of bomber aircraft by fighters. The equipment has been developed under the auspices of the North Atlantic Treaty Organization for use by the Italian Army.

The installation includes seven desk consoles each containing circuits for generating pulses which, when applied to the display oscillograph of a radar receiver, appear as normal aircraft echoes. Each console can simulate two aircraft. Means are provided in the consoles for moving an 'aircraft' along any desired track at speeds which may be varied between its stalling and maximum speeds. Controls are also provided for rate of turn and rate of climb, again in accordance with the capabilities of the aircraft being simulated.

All 'echoes' are displayed on a central plan position indicator from which the general state of the exercise may be studied.

The echo signals, which may be designated as originating from friendly or enemy aircraft as desired, are also displayed on the plan position indicators of a radar receiver. In so doing, the apparatus takes into account the horizontal and vertical radiation patterns, including side lobes, of the aerials of the radar being simulated. These plan position displays enable interception techniques to be practised by a controller who telephones instructions to the operator of the desk console simulating the fighter, who varies the course of the fighters so as to bring about interception of the bombers. Bomber control may be carried out if required by a controller at another plan position indicator.

An interesting adjunct to the equipment is the simulation of electronic radar counter-measures both by parachuted noise jammers and by the dropping of strips of metal foil ('window'). In both cases means are provided in the equipment to take into account the effect of the prevailing wind on the drift of the jammers.

In the design of this versatile installation, the likelihood of future changes in the performance of aircraft and radar, and of air defence procedure in general, have been borne in mind, and the necessary modifications and additions to the installation to deal with such changes are readily made.

Equipment similar in principle to that demonstrated may be used for simulating marine exercises in which both radar and asdic are used, and it may also be used for training in civil air-traffic controls.

A. F. Wilkins

CHEMISTRY AND QUANTUM CHEMISTRY

IN the course of the past twenty-five years the language of quantum mechanics has invaded almost every branch of chemistry. Often this has been at a very qualitative level involving only such basic concepts as those of stationary states and energy-levels. Many of the most useful ideas, however, are ones which do not belong to accurate quantum mechanics but arose first in certain approximate calculations and have since been developed by using them to explain experimental facts. These range from the idea of a crystal potential which is used to make qualitative predictions about molecular complexes, to ideas such as hybridization and resonance which are used qualitatively to describe the structure and reactivities of molecules. Unfortunately, it is becoming very clear that most of these ideas need careful re-examination both to establish their quantum mechanical status and to show how they can be refined or modified to explain the more extensive and more accurate experimental results now available.

It was very appropriate, therefore, that this problem of the correspondence between the concepts of chemistry and those of quantum chemistry should have been the subject of a panel meeting held at Vålådalen, in the Swedish mountains, during August 26–30 and organized by Dr. P. O. Löwdin, director of the Quantum Chemistry Group in Uppsala. The audience consisted primarily of experimentalists who had spent the previous month there at the summer school on quantum chemistry, and the panel included both chemists and quantum chemists. The meetings were pleasantly informal, and, since the number of prepared contributions was deliberately kept small, there was ample time to discuss fundamental problems.

The theory of molecular structure based on the overlapping of hybrid atomic orbitals which are concentrated in the bond directions was one topic discussed, and in particular the idea of assigning a constant atomic radius to each kind of hybrid. Experimental methods of determining molecular structure using micro-waves, electron diffraction and X-rays were reviewed by Prof. B. Bak (Copenhagen), Prof. K. Hedberg (Oregon), Prof. O. Bastiansen (Trondheim) and Dr. I. Lindqvist (Uppsala), and they reported that the accuracy and flexibility of these methods had recently increased considerably. The results were shown by Prof. Bak and Dr. I. Hjalmars (Stockholm) to imply that the approximation of a constant radius for each hybrid is often accurate to 0·001 A. Furthermore, as Prof. L. Pauling (Pasadena) showed, the rotational barriers can be predicted by including in the hybrids small amounts of higher angular terms, and the experimental confirmation of these predictions was discussed by Prof. L. Pierce (Notre Dame). On the other hand, Dr. Löwdin pointed out that the principle of maximum overlapping is quantitatively inaccurate even on an approximate theory and that the accurate theory does not even give any unique hybrids. In consequence, it is difficult to believe that the hybrids have any physical reality. Prof. R. S. Mulliken (Chicago) agreed that there is still no basic theoretical reason why covalent radii should be so constant.

There was general agreement on the artificial nature of the distinction often made between ionic and covalent binding. Both Dr. S. Lundqvist (Uppsala) and Prof. H. Shull (Indiana) pointed out that ionic wave-functions can sometimes give covalent properties and be almost identical with corresponding covalent wave-functions. This led naturally to a discussion of the method of 'atoms in molecules' which uses such wave-functions. Dr. R. Pauncz (Haifa) showed that, when the method is applied literally to hydrogen, the results are rather poor, but Dr. H. Preuss (Göttingen) defended the method in a modified form. It seems clear that the unmodified free atoms or ions do not provide the best units for describing the compound.

The concept of hyperconjugation is also in some difficulties. This type of delocalization of the electrons plays an important part in the excited states and ionized states of many molecules and in transition complexes, but it is not so clear that it is important in molecular ground-states. The concept was strongly defended by Prof. Mulliken, and he claimed that there is sufficient experimental evidence to substantiate it even for the ground-state. The concept of conjugation also has recently been attacked, but Prof. Mulliken thought this was because the simple Hückel theory sometimes exaggerated its effects, for example, in butadiene, whereas more recent theories give much better agreement with experiment. Dr. R. McWeeny (Keele) argued that the study of diamagnetic susceptibility and proton magnetic resonance gives very strong evidence for conjugation, although Prof. Bak and Mr. R. A. Hoffman (Uppsala) pointed out that some proton magnetic resonance effects in conjugated molecules are not yet understood. Dr. S. Sunner (Lund) talked about difficulties in understanding resonance and strain energies and suggested that these are often due to the use of unrelated or inappropriate reference states.

A point which emerged clearly from the discussion is the growing tension between the so-called semi-empirical methods and those based on *a priori* calculations. Mr. C. Schäffer (Copenhagen), for example, described the successful use of crystal-field theory in explaining the spectra and properties of molecular complexes. Yet, as Dr. Löwdin insisted, the model does break down when refined too far and the empirical values of the parameters do not agree with those calculated. The resonance theory is another example of a theory which is still useful qualitatively and semi-quantitatively despite the fact that some of its assumptions are in serious error. The success of the simple Hückel theory, according to Dr. G. G. Hall (London), is not due to the accuracy of its assumptions but to the mathematical resemblance between its equations and those of a more accurate theory, and it may be that such resemblances occur for other theories.

The urgent need for more accurate theories and concepts appropriate to them was felt several times during the meeting. Dr. H. G. Bennewitz and Dr. G. Gräff (Bonn) underlined it by describing molecular-beam experiments which yield very accurate values of many molecular constants. Prof. F. A. Matsen (Texas) and Dr. Hall favoured the method of different orbitals for different spins as a method more accurate than that of molecular orbitals yet as easy to visualize. There was also a vigorous discussion on the rival merits of natural orbitals and population analysis as methods of understanding complicated wave-functions.

A discussion of the future of quantum chemistry provoked some differences of opinion. In the view of Prof. Mulliken, the calculation of good molecular orbital wave-functions, which is now beginning, will help greatly to clarify molecular structure and will enable generalizations about correlation energies to be made. Dr. Löwdin thought that the effects of correlation and relativistic corrections will be of importance in many chemical problems and should be investigated using more accurate wave-functions. On the other hand, Dr. Hall believed that *a priori* calculations will never be possible for more than a small number of molecules and that it is just as important to study accurately the relations between the molecules of a molecular series. Prof. Matsen considered that the experimentalists' need for concepts with which to organize and understand their results is so urgent that they may be forced to invent these without waiting for the development of quantum mechanical ones. It was Prof. Pauling's hope that the present introspective phase of quantum chemistry, though obviously necessary, will not last very long, since there are many urgent chemical problems which could be solved more easily theoretically than experimentally.

G. G. HALL

NATURAL SELECTION IN MAN

IN a year marked by the celebration of the Darwinian–Wallace centenary, it is fitting that a symposium, sponsored by the Society for the Study of Human Biology and held on November 8 in the Department of Anatomy, University College, London, should have focused attention on modern analyses of the action of natural selection in human populations. The symposium comprised six papers, and in five of these attention was directed to a greater or lesser extent towards genetical matters, knowledge of which is basic to studies of the promotion of evolutionary change by selective forces. In the final contribution, the field was still further expanded by the consideration of a number of broader questions connected with primate (including human) evolution.

The balance of the whole symposium was such as to indicate clearly the extent to which, despite much intensive work, knowledge of many aspects of human inheritance and selection theory still falls short of that now available for some other animal species. Little is known, for example, of the multifactorial control of quantitative human features ; but, on the other hand, a considerable body of information has accumulated in relation to certain groups of major human genes, and several speakers addressed themselves to problems associated with the action of selection upon individuals distinguished by the possession of easily identifiable allelomorphs.

Two of several problems basic to present-day studies of natural selection in man are, as pointed out by Prof. L. S. Penrose (University College, London) in an opening paper, the recognition of these major genetic factors and the determination of the frequencies at which they exist in different populations. The first of these aims has, in many cases, now been attained by analyses of the human pedigrees to the compilation of which much early work was directed. The second has only been achieved on any considerable scale in the case of such factors as those which determine the blood groups, but in this particular case, data are now available from widely scattered regions of the world.

Genetic factors of this type must, as pointed out in the opening paper, have arisen at some time by mutation, but such origins of new variability are rarely recorded. Thus, despite the thoroughness with which the blood-group systems have been studied, mutation in them has not been observed. Indirect evidence, however, indicates its occurrence, sometimes at relatively high rates. Achondroplasia, for example, results from the effect of a single dominant major gene which has in certain populations remained in circulation for long periods. The condition is associated with a marked degree of infertility, and the genetic wastage which thereby results must presumably be made good continually by new mutation.

Recessive genes which, when substituted in double dose into certain genetic complexes, may exert markedly deleterious effects on viability exist in heterozygous form in all populations. They provide a source of potential variability which if liberated would, even in the absence of mutation, form an adequate basis for considerable amounts of evolutionary change. The scope and selective significance of this potential variability are difficult to assess from the available human data, but a reminder of their extent was given by Prof. Th. Dobzhansky, who, as the guest speaker, presented in outline the results of his own extensive work on the hidden genetic variability in wild populations of *Drosophila*.

The selective significance of each factor may be suggested by studies of the effects which it exerts on the processes of growth and development. This aspect of human genetics is still little explored, but a measure of the selective significance of any factor is given by the reproductive 'fitness' which it confers upon the individual. The estimation of fitness presents a number of technical difficulties, which were outlined in a paper by Dr. C. A. Clarke (University of Liverpool). Basically, the problem involves an assessment of the numbers of offspring which reach reproductive age, produced by individuals carrying the mutant allelomorph, relative to those produced by remaining members of the population. The value so obtained measures fitness in only a single selective environment, and, apart from the difficulties associated with the identification of individuals carrying recessive mutants as heterozygotes, sampling bias may be introduced as a result of undue attention being directed towards the families which carry mutant allelomorphs. A further source of inaccuracy arises from the fact that fertility is influenced by numbers of genetic factors additional to the one in question, and these may not be randomly distributed among unrelated individuals carrying the normal and mutant genes. Errors of this type can, to a large extent, be eradicated by the use of sib comparisons, but in this case further uncertainty exists as to whether or not the reproductive capacity of the 'normal' brothers and sisters is representative of that of the population as a whole.

Variations in the fitness conferred by different allelomorphs result in their existing at different frequencies, and it was to a formal mathematical analysis of the maintenance by selective forces of this type of polymorphism that Dr. A. R. G. Owen (University of Cambridge) addressed himself in a paper entitled "Mathematical Models for Selection". In this field, present studies relate exclusively to genes at a single locus, and for stability to be achieved in the relative frequencies of two or more allelomorphs it is necessary that each homozygote should have a fitness less than the average for the population as a whole. The frequency of each allelomorph is broadly related to the fitness which it confers, but when three or more are involved, complex relationships, not only between the viabilities of the various homozygotes but also between those of different heterozygotes, must be satisfied before a stable equilibrium can be achieved. Slight shifts in selective pressure can cause marked changes in the polymorphic balance, while selection acting differentially upon genotypes derived from the male or female parent may result in a dynamic polymorphism in which the frequencies of different allelomorphs vary continually without, however, any allele becoming extinct.

That the maintenance of polymorphism in the frequencies of human genes depends on selective factors now admits of little doubt, and it was in the contribution by Dr. P. M. Sheppard (University of Liverpool) that emphasis was laid on the fact that genes, the presence of which can easily be detected by analyses of characters apparently devoid of selective significance, often exert secondary effects which influence the fitness of the individual to an extent sufficient to establish a polymorphism. Among such genes, the factors which determine the blood groups are probably the best known. Possession of the gene for blood group A is associated with a tendency to develop cancer of the stomach, while the factor for blood group O is, in the presence of the 'non-secretor' gene, associated with an increased incidence of duodenal ulcer. Again, while individuals who are able to taste phenylthiocarbamide are predisposed to the development of diffuse goitre, those unable to taste this compound exhibit an increased incidence of nodular goitre.

In certain instances complex relationships between the selective significance of different series of allelomorphs arise as a result of interactions between the physiological characters which they influence. For example, the selective disadvantage which results from incompatibility between mother and fœtus in either the Rh or ABO series of allelomorphs is largely neutralized if the incompatibility exists in both series simultaneously.

Certain quantitative features (for example, skin colour) are known to have adaptive significance, while others (for example, intelligence) are correlated with fertility and viability. There would seem to be no reason to doubt that the selective forces thus set up have, by their action upon isolated populations, produced the well-defined differences which now exist between the major human sub-groups. In human populations, however, there are, as recently elaborated by Sir Julian Huxley, certain unusual selective forces in operation. These arise from man's unique capacity for abstract thought—a feature which is correlated with the marked cerebral enlargement that has occurred in the course of human evolution. Cerebral enlargement has, in turn, been associated with marked modifications in the cranial and facial skeleton, while concurrently there have arisen in the post-cranial skeleton numerous distinctive features consequent upon man's assumption of an upright posture.

The final paper in the symposium contained a general discussion of certain problems associated with the study of the evolution of these unique human features. Following a brief review of the various phases of the primate radiation between the Eocene and the present day, Dr. E. H. Ashton (University of Birmingham) submitted that as the numbers of available fossil primates are small, and as conspicuous gaps exist in the record of each sub-group of the order, little can be inferred about the anatomical nature of the immediate ancestors of *Homo sapiens*. As a corollary it was suggested that whatever significance may be attached to such controversial groups as *Oreopithecus* and the South African Australopithecinae, it is not feasible to assess the point at which the human stock, which does not appear in an undisputed form until part of the way through the Pleistocene, diverged from the apes, the first representatives of which date from the Lower Oligocene. Consequently, the rate of evolutionary change in each line is indeterminate.

One set of observations does, however, show that in the extant subhuman primates measurable amounts of morphological change can occur in exceptionally short periods of time. A colony of the West African green monkey (*Cercopithecus aethiops sabaeus*) which has been isolated for a mere hundred generations on the West Indian island of St. Kitts now differs significantly in cranial and dental features from the present-day African descendants of the parental stock. The St. Kitts monkey is now not only bigger, but also its cranial and dental dimensions are less variable than in the African variety. On the other hand, while its skull is less symmetrical, certain non-quantitative features of the teeth of the island monkey are now more variable than in the mainland variety. Although the possibility cannot be excluded that this complex of change has resulted from the direct action of a changed environment on an unaltered genetic constitution, parallels with complexes of change recorded in laboratory experiments with lower animals suggest that the differences may have, as a basis, changes in systems of multiple genes. In this case, the observations would represent an example, at present unique, of the effect of selective forces upon a primate population.

E. H. Ashton

WOMEN IN ENGINEERING

PROBABLY the most persuasive case for the employment of professional women in industry has been made by the Women's Engineering Society. Unlike other women advocates who rely either on wistful laments or on emotional over-statements of unestablished truths, the Women's Engineering Society bases its case on hard-won knowledge of industry and on the records of those courageous and enterprising women engineers who have already made successful careers for themselves in industry. In a booklet prepared by members of the Careers Panel of the Society, it is shown that there is now no reason why a girl with talent and determination should not embark on an engineering career with every prospect of success (Training and Opportunities for Women in Engineering, 25 Fouberts Place, London, W.1. 3*s.* 6*d.*). She is advised, however, to equip herself fully with formal qualifications, like membership of professional institutions and those obtained by examination, such as a university degree in engineering or a Higher National Certificate. "Engineering training has two distinct components, theory and practice, and both are equally necessary to the would-be engineer. The former can be obtained in Universities and Technical Colleges, while, for most branches of the profession, the best practical training is provided in industry." It is in obtaining this practical training that the girl student may find herself at a disadvantage compared with her brother. Entry into certain branches of engineering is easier than into others, and there is more prejudice against the employment of women in certain positions than in others. The new branches of engineering such as aeronautics, electrical and electronic engineering, or heating and ventilating, offer an easier entry to women than do the older branches such as marine or locomotive engineering, naval architecture or civil engineering.

There is still a prejudice against putting women in control of large numbers of men, and few firms the employees of which are mostly male would consider appointing a woman as works manager or foreman. There is far less prejudice against the employment of women in scientific work, design or research.

The booklet describes the training and qualifications required in many branches of engineering as well as the posts available when training is complete.

WATER POLLUTION RESEARCH, 1957*

MUCH of this tightly packed report will be of interest only to those who are directly concerned with sewage treatment and pollution, and the thirty-two papers published by members of the staff during the year have nearly all appeared in technical journals. Some of the work is of wider appeal, and merits fuller mention than the rest in a journal of general science such as *Nature*.

Various calculations have been made to find the most economical way of improving the Thames estuary. Aeration of some of the worst inflows has been suggested, but it is shown that the effect of this would not be great. An increase in temperature would lead to an immediately greater oxygen deficit but a corresponding amelioration farther down the river. It has been found that, especially at higher temperature, nitrate may be reduced before the concentration of oxygen approaches zero, a hitherto unsuspected complication in calculations of this kind. Even after the completion by the London County Council in about 1962 of alterations and extensions to its sewage works, the Thames will still be foul. Sulphide, perhaps, will no longer be formed in the central reaches of the estuary, but oxygen concentration will be low.

Fig. 13 of the report shows how oxygenation of water passing over a weir increases with the height of the weir, rapidly at first but gradually more slowly, a 9-foot weir, the highest tested, being only slightly more advantageous than one 8 feet high. The effect depends also on the depth of the basin into which the water falls; with a 5-foot fall the concentration of oxygen increases quite markedly up to a depth of 8 inches, but thereafter is the same for all depths. Another experimental set-up of general interest is the channel for studying temperature gradients. It is 500 feet long and is made by setting baffles across a tank. The object is to study the behaviour of fish in a temperature gradient; but first it will be necessary to study the nature of the gradient under different conditions of flow, humidity and initial temperature. Some figures are presented here, but it is hoped that more will be forthcoming and their relation to the results of theoretical calculations discussed. The continuous recorder for dissolved oxygen, on its way to becoming a standard instrument, has been developed and improved by the incorporation of a device for automatic temperature compensation, which is described.

The amount of effluent necessary for a satisfactory test of toxicity is inconveniently large if the fish used is more than about 1 inch long, and foreign fish have been used since no British species is as small as this when adult. The apparatus designed for routine tests is described and figured. Zinc is shown to be toxic at lower concentration in soft than in hard water, rainbow trout, for example, dying in less than three days in 0·5 p.p.m. zinc in soft water and surviving ten days in six times that amount in hard water. Experiments with a radioactive tracer suggest that the effect of the zinc may be internal and not merely on the gills as hitherto believed.

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* Department of Scientific and Industrial Research. Water Pollution Research 1957: The Report of the Water Pollution Research Board with the Report of the Director of the Water Pollution Research Laboratory. Pp. iv+100+4 plates. (London: H.M. Stationery Office, 1958.) 6*s.* net.

Various mixtures likely to be produced by coke ovens are more toxic than pure phenols, and their effects are enhanced by low oxygen concentration. Biological treatment is sometimes successful, but not when substances containing much ammonia are present. Cyanide, too, has been successfully broken down in a biological filter, and experiments have been carried out on an anaerobic digestion process for certain trade wastes. It has been found a satisfactory method of dealing with the effluents from slaughter-houses and whisky distilleries.

The nature and concentration of the constituents of domestic sewage, about which little is known, are under investigation. It now seems clear that synthetic detergents reduce the rate at which oxygen is absorbed in the activated sludge process, and this may account for reports of decreased efficiency of certain plants in recent years. T. T. MACAN

CHEMICAL DESTRUCTION OF MATURE PERITHECIA OF *MYCOSPHAERELLA PINODES*

By M. V. CARTER
Waite Agricultural Research Institute, Adelaide

RECENT research work with dinitro-ortho-cresol, pentachlorophenol (and their sodium salts) and phenyl mercury compounds as eradicant fungicides has been aimed mainly at preventing the normal maturation of ascocarps of various fungal pathogens, as distinct from destroying mature ascocarps. Pathogens in which ascospore discharge has been controlled successfully by the application of these compounds prior to maturation of the perithecia apparently all belong to the group of Ascomycetes which complete their life-cycles during a long over-winter saprophytic phase in fallen leaves, mummified fruits, or branch cankers, for example, *Venturia inequalis*[1], *Pseudopeziza ribis*[2], *Sclerotinia* spp.[3], *Nectria galligena*[4].

In South Australia, where large areas of garden peas for fresh marketing are grown under sprinkler irrigation in districts of low natural rainfall (12 in. or less per annum), extensive damage to crops by *Mycosphaerella pinodes* is common. Under optimum conditions, mature perithecia of this fungus may be produced within two weeks from the time of infection: there are thus many generations of ascospores during a single pea-growing season.

Phenyl mercuric chloride was found to be ineffective in destroying mature perithecia of *M. pinodes* when applied at a concentration of 0·1 per cent, as used for autumn spraying for eradication of *V. inequalis*.

In the first series of laboratory tests with pentachlorophenol, an oil-and-water emulsion containing 0·75 per cent of the chemical was applied by means of a 'Rega' hand atomizer to a series of 5–10 gm. samples of heavily infected pea straw from the 1957 crop, collected from the field in February 1958. Control samples were treated with distilled water. Beginning two days after the treatments were applied, and at weekly intervals thereafter for the next seven weeks, ascospore discharge was tested by immersing each sample in water for 5 min., draining for 5 min., and suspending in a wire basket under a bell-jar 6–7 in. above the orifice of a Hirst-type spore impactor[5], which was then operated for 1 min.

Table 1. NUMBERS OF ASCOSPORES* OF *Mycosphaerella pinodes* DISCHARGED FROM PEA STUBBLE SAMPLES AFTER TREATMENT WITH 0·75 PER CENT PENTACHLOROPHENOL

Days after treatment	Control (water only) 1	2	3	4	5	0·75 per cent pentachlorophenol 1	2	3	4	5
2	869	1,056	1,159	622	327	68	3	17	12	3
9	155	1,999	1,625	1,126	711	40	1	0	12	0
16	488	637	2,003	1,129	489	4	2	2	0	1
23	2,056	3,612	8,622	5,672	808	9	0	2	7	4
30	843	850	840	2,310	345	9	2	0	3	2
37	1,272	1,758	1,559	1,365	792	10	9	0	79	0
44	813	977	1,881	706	992	4	0	0	11	0
51	286	1,517	248	206	34	2	1	1	2	0
Totals	6,782	12,406	17,937	13,136	4,498	146	18	22	126	10

* Each count is the sum of 10 traverses across the zone of spore deposit on a microscope slide, using a magnification of 480

Table 2. NUMBERS OF ASCOSPORES* OF *Mycosphaerella pinodes* DISCHARGED FROM PEA STUBBLE SAMPLES AFTER TREATMENT WITH PENTACHLOROPHENOL AT VARIOUS CONCENTRATIONS

Days after treatment	Control (water only)			Pentachlorophenol (per cent)														
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
2	598	2,006	392	39	68	34	3	0	0	0	0	0	0	3	0	1	0	0
9	8,180	2,510	1,860	125	2	37	0	0	0	0	0	0	0	0	0	0	0	0
16	Not counted			27	3	1	0	0	0	5	0	0	0	0	0	0	0	0
23	3,988	>10,000	4,094	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
30	>10,000	>10,000	>10,000	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0
Totals	>22,000	>24,000	>16,000	191	81	77	3	0	0	5	0	0	0	3	0	1	0	0

* Each count is the sum of 10 traverses across the zone of spore deposit on a microscope slide, using a magnification of 480

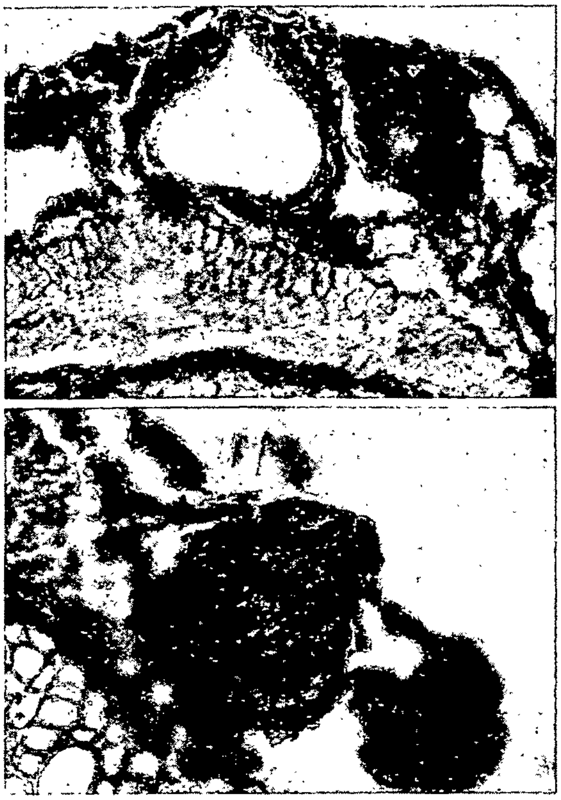

Fig. 1. Top, perithecia of *M. pinodes* treated with 0·75 per cent pentachlorophenol; bottom, normal (untreated) perithecium of *M. pinodes*

The spore counts given in Table 1 suggested that this concentration of pentachlorophenol had a powerful fungicidal effect on mature perithecia of *M. pinodes*, but that the method of application had not given complete coverage.

The second series of laboratory tests was designed to determine the effect of a range of concentrations of pentachlorophenol on 10-gm. samples which were momentarily immersed in the emulsion in order to ensure complete coverage. Spore discharge was assessed in the same way, beginning on the second day after treatment and continuing thereafter at weekly intervals for five weeks. Spore counts are given in Table 2, and these indicate a highly efficient kill of perithecia with all concentrations of pentachlorophenol down to 0·2 per cent.

After each of the first four discharge tests, the samples were allowed to dry in air. After the fifth discharge, all the samples were showered with ascospores of *M. pinodes* and incubated moist in closed containers at room temperature to determine whether recolonization by the fungus could occur at this stage. Straws untreated with pentachlorophenol but steam-sterilized were also subjected to a similar inoculation and incubation.

A very heavy mycelial growth was present on the steam-sterilized straws after incubation for five days; that on the unsterilized untreated controls was less conspicuous, possibly due to partial inhibition by strong bacterial growth. A few isolated colonies were noted on all the samples treated with pentachlorophenol except those which had received the 2 per cent treatment.

In order to examine histologically the effect of pentachlorophenol on the perithecia, representative straws from 0·75 per cent pentachlorophenol and from control samples were embedded in paraffin wax and sectioned by microtome at 10μ. The chemical completely destroyed the contents of the perithecia, which appeared either empty or with a few disorganized remains in the asci, as shown in Fig. 1 (top). Sections of normal untreated perithecia are shown in Fig. 1 (bottom).

Preliminary tests have shown that dinitro-ortho-cresol (0·2 per cent) and dinitro-secondary butylphenol (0·2 per cent) may be expected to give similar results.

Field experiments with certain of these chemicals are proceeding; but observations to date indicate that the technical difficulties of obtaining a sufficiently complete spray coverage of the pea stubble will present a serious obstacle to successful application of the method for field control of the pathogen.

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OXIDATION OF ASCORBIC ACID AND SIMILAR REDUCTONES BY NITROUS ACID

By DR. C. A. BUNTON

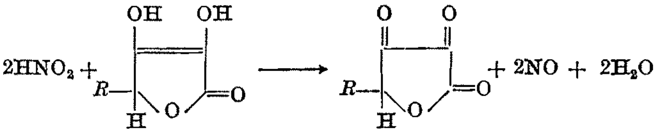
Department of Chemistry, University College,
London, W.C.1

AND

PROF. H. DAHN and DR. LOTTE LOEWE

Organisch-chemische Anstalt der Universität,
Basel

THE reaction between ascorbic acid and sodium nitrite or nitrous acid was first observed by Karrer and Bendas[1]. This reaction is general for reductones (that is to say, enediols stabilized by conjugation to a carbonyl or similar group)[2,3]; it has the characteristics of a typical oxidation-reduction process, and gives quantitative formation of nitric oxide and dehydro reductone. For example:

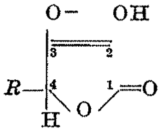


(I*a*), Ascorbic acid (R = $CH_2OH.CHOH—$)
(I*b*), Phenyl hydroxytetronic acid[3]
(R = $C_6H_5—$)

(II*a*), (R = $CH_2OH—CHOH—$)
(II*b*), (R = $C_6H_5—$)

The optimum conditions for these reactions (in aqueous solutions at $pH < 5$) are similar to those in which nitrosation at nitrogen and oxygen occurs[4,5], and we sought and have found a parallel between the oxidation of reductones, and the diazotization of aromatic amines[4], and the exchange of oxygen atoms between water and nitrous acid[5].

The compounds (I*a*) and (I*b*) have characteristic absorptions[6] which are more intense than those of the dehydro reductones (II*a*) and (II*b*) and of nitrous acid, and the reaction can be followed by spectrophotometric methods. The 3-hydroxyl group of (I*a*) and (I*b*) is acidic ($pK_a \sim 4$), while that on C–2 is enolic ($pK_a \sim 12$)[7]. Thus at $pH < 5$ the acid (I) and its mono-anion (III) co-exist.



(III)

The kinetics of the oxidation of ascorbic acid (and to a limited extent of phenyl hydroxytetronic acid (I*b*)) have been examined in detail at 0° C. in aqueous dioxan. A few runs were made in water, but in some conditions the reaction in water is too fast for convenient measurement. In all cases the concentration of the reductone ($0 \cdot 1$–$0 \cdot 2 \times 10^{-3}$ *M*) was much less than that of the nitrous acid ($0 \cdot 8$–$8 \cdot 0 \times 10^{-3}$ *M*).

With sodium nitrite in excess over nitrous acid (pH 3–4 in water) we observe the rate-law for reactions in both water and aqueous dioxan:

$$v = k_2 [HNO_2]^2$$

The kinetic form of an individual run is of zeroth-order in reductone and the rate is almost independent of the nature and concentration of the reductone:

$$\begin{aligned} (\mathrm{I}a),\ 10^2 k_2 &= 1 \cdot 7 \ (\mathrm{mol.}^{-1}\ \mathrm{l.sec.}^{-1}) \\ (\mathrm{I}b),\ 10^2 k_2 &= 1 \cdot 5 \ (\mathrm{mol.}^{-1}\ \mathrm{l.sec.}^{-1}) \\ (0^\circ\ \mathrm{C.};\ \mathrm{dioxan} &: \mathrm{water} :: 40 : 60\ \mathrm{v/v}) \end{aligned}$$

Following the interpretation given to such a kinetic form in the diazotization of the aniline[4], we conclude that the step *determining the rate* of the reaction is the formation of dinitrogen trioxide.

Reaction path A :

$$\begin{gathered} 2HNO_2 \rightleftharpoons H_2NO_2^+ + NO_2^- \\ (1) \\ \downarrow \\ H_2NO_2^+ + NO_2^- \rightleftharpoons N_2O_3 + H_2O \\ (2) \\ N_2O_3 + \text{reductone} \rightarrow \text{intermediate (IV)} \\ (3) \\ (\mathrm{IV}) \xrightarrow[\text{(fast)}]{\text{nitrous acid}} (\mathrm{II}) \\ (4) \end{gathered}$$

In this acidity region most of the reductone is present as a mono-anion (III); we assume that the dinitrogen trioxide reacts rapidly with this mono-anion (step 3), to give an intermediate (IV), which then reacts rapidly with a further nitrous acid species to give the final products. (The probable nature of the intermediate is discussed below.) This kinetic scheme requires that the rate of reaction of the reductone in water should be close to that of the zeroth-order diazotization of aniline[4], and the oxygen exchange of nitrous acid via dinitrogen trioxide[5]: this is so within the limits of experimental uncertainty.

$$\begin{aligned} k_2 &= 0 \cdot 49 \ (\mathrm{mol.}^{-1}\ \mathrm{l.sec.}^{-1}) \ (\text{oxidation of } (\mathrm{I}a)) \\ &= 0 \cdot 85 \ (\mathrm{mol.}^{-1}\ \mathrm{l.sec.}^{-1}) \ (\text{diazotization})^4 \\ &= 0 \cdot 53 \ (\mathrm{mol.}^{-1}\ \mathrm{l.sec.}^{-1}) \ (\text{oxygen exchange})^5 \\ &\quad (0^\circ\ \mathrm{C.};\ \text{water}) \end{aligned}$$

At the other extreme of our acidity-range (with $[HClO_4] \gg [HNO_2]$) we observe a different kinetic form:

$$\begin{gathered} v = k_3{}^{0H} [H^+] [HNO_2] [\text{ascorbic acid}]; \\ k_3{}^{0H} = 7 \cdot 5 \ (\mathrm{mol.}^{-2}\ \mathrm{l.}^2\ \mathrm{sec.}^{-1}) \\ (0^\circ\ \mathrm{C.};\ \text{dioxan} : \text{water} :: 40 : 60\ \mathrm{v/v}) \end{gathered}$$

(So far, this region has been explored only for the oxidation of ascorbic acid in aqueous dioxan.) With an excess of perchloric acid (about $0 \cdot 1$–$1 \cdot 0$ *M*) the concentration of ascorbate ion is very low, and we consider the mechanism to be a slow reaction between the nitrous acidium ion (V) and ascorbic acid.

Reaction path B :

$$\begin{gathered} H^+ + HNO_2 \rightarrow H_2NO_2^+ \ (\mathrm{V}) \\ (\mathrm{V}) + \text{ascorbic acid} \rightarrow \text{intermediate (IV)} + H^+ \end{gathered}$$

followed by a rapid reaction of the intermediate (IV). This process has its analogy with N- and O-nitrosations, for example, the diazotization of aromatic amines in acid[4], and the acid catalysed hydrolysis of alkyl nitrites[8].

In the acidity-range between those which show mechanisms *A* and *B* there is a region in which the kinetics are of mixed order. Part of the reaction proceeds by mechanism *B*, but there is also a rate term which is second order in nitrous acid and first order in stoichiometric reductone. A similar kinetic form has been observed for reactions between nitrous acid and both aliphatic and aromatic amines[4,9]. It arises because in this region dinitrogen trioxide is in facile equilibrium with nitrous acid (steps 1 and 2 of mechanism *A*), but the proportion of the highly reactive reductonate ion is now very low (< 0·1 per cent), and so the reaction with dinitrogen trioxide (step 3 of path *A*) is slow. A detailed examination of the effect of changes in acidity and nitrous acid concentration upon the reaction-rate between nitrous and ascorbic acids shows that in the region $[H^+] = 10^{-4}$–10^{-3} *M*, dinitrogen trioxide reacts with both ascorbic acid and ascorbate ion, and it is possible to estimate the relative reactivities towards dinitrogen trioxide:

$$v = [HNO_2]^2 \{k_3{}^0 [\text{ascorbic acid}] + k_3{}^- [\text{ascorbate}]\}$$

$k_3{}^0 = 73$ ($\mathrm{mol.}^{-2}\ \mathrm{l.}^2\ \mathrm{sec.}^{-1}$); $k_3{}^- = 1 \cdot 15 \times 10^5$ ($\mathrm{mol.}^{-2}\ \mathrm{l.}^2\ \mathrm{sec.}^{-1}$) (0° C., dioxan : water 40 : 60 v/v).

Thus we have reactions of the powerfully electrophilic nitrous acidium ion with the undissociated reductone, and of the weakly electrophilic dinitrogen trioxide with both the undissociated reductone and its more reactive anion.

Chloride and bromide ions catalyse the oxidation of ascorbic acid by nitrous acid by forming nitrosyl halides, which are themselves powerful nitrosating agents[4].

$$H_2NO_2{+} + X^- \rightleftharpoons NOX + H_2O$$

$$NOX + \begin{Bmatrix}\text{ascorbic acid}\\ \text{ascorbate ion}\end{Bmatrix} \rightarrow \text{intermediate (IV)} + \begin{Bmatrix}HX\\ X^-\end{Bmatrix}$$

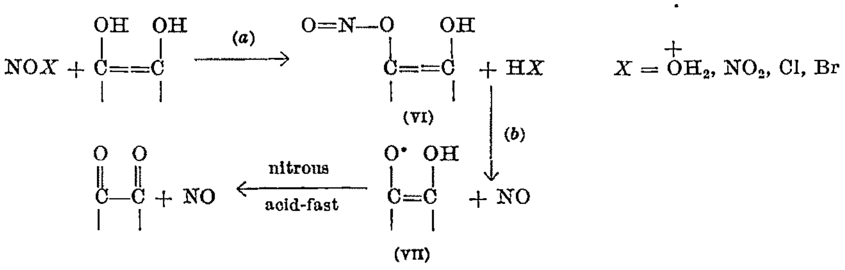
$$(X = Cl, Br)$$

From our kinetic results we can calculate specific rate-constants for the processes, and estimate the relative reactivities of various species towards dinitrogen trioxide and the nitrous acidium ion. In making these calculations we have ignored effects due to activity changes; these should not be large because the ionic strengths of the solutions are low, and approximately constant. Some of the numerical values are uncertain, because they are derived from small differences between large quantities.

We can formulate the reaction between a nitrosating agent and a reductone in various ways. Perhaps the simplest is a preliminary electrophilic attack upon the reductone (*a*), with formation of a nitrite (VI), which then decomposes (*b*).

It is, of course, possible that steps (*a*) and (*b*) may be synchronous, and the process would then be considered as a transfer of a single electron to the nitrosating agent. In either event we conclude that the first step of reaction between a nitrosating agent and a reductone, forming the semiquinone (VII) (which may be identical with the above-mentioned 'intermediate' (IV)), is followed by a rapid reaction between (VII) and nitrous acid, or some species in equilibrium with it.

It seems to us that there is, therefore, a very close similarity between this oxidation – reduction reaction and the well-characterized heterolytic nitrosations by electrophilic reagents.



This work forms part of a research programme on reductones, sponsored by the Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung, to which we express our thanks. A full account of the present work will be given in *Helvetica Chimica Acta.*

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A TWO-DIMENSIONAL PAPER CHROMATOGRAPHIC METHOD COMBINING ION-EXCHANGE AND PARTITION TECHNIQUES

By C. S. KNIGHT

Research Laboratories, W. and R. Balston, Ltd., Springfield Mill, Maidstone, Kent

ALTHOUGH the two-dimensional paper chromatographic method has been successfully applied to separations involving a wide range of substances, improvements and modifications are continually being proposed to make this technique even more discriminating.

Separations can often be improved by increasing the complexity of one or more of the conditions under which a chromatogram is developed, as, for example, in the use of three- or four-component solvent mixtures. On the other hand, the use of simple conditions to increase the reproducibility is often insufficient to effect an adequate separation. Thus, some approach between the two extremes has to be adopted. The present method, however, offers a means of increasing reproducibility in addition to separability.

This new approach to paper chromatography comes as a result of the development of a range of Whatman ion-exchange celluloses in these Laboratories. These new materials have been prepared by introducing acidic or basic groups into the cellulose molecule such that, under favourable conditions, ion-exchange involving these groups will be the dominating factor in a chromatographic separation[1]. Where, however, it is possible to suppress the activity of these groups such that ion-exchange is no longer the dominating factor, any chromatographic separations under such conditions will be largely as a result of a partition-type mechanism similar to that on unmodified cellulose. On the one material, in paper form, therefore, it is possible to combine ion-exchange and partition techniques in the form of a two-dimensional chromatogram, and this very simply is the basis of the method described below.

The ion-exchange materials investigated contained medium or weak strength functional groups such that where necessary their ion-exchange properties can be suppressed to varying extents by addition of acid or alkali to a developing organic solvent. Details of some separations investigated are as follows.

(1) Phosphorylated cellulose, containing dihydrogen phosphate groups, was used in the form of its mono-ammonium salt. A mixture of copper, manganese, cobalt, cadmium, iron, bismuth, zinc and mercury was applied as a spot near one corner of a

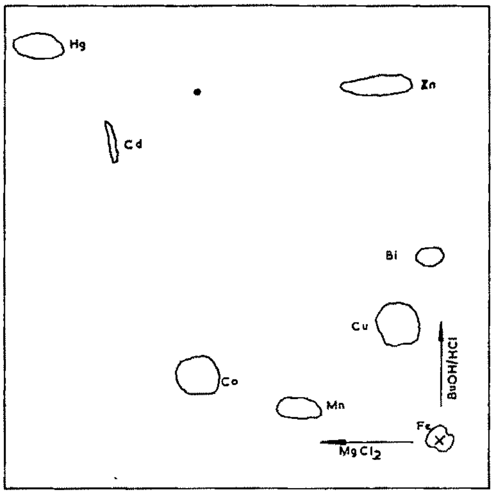

Fig. 1

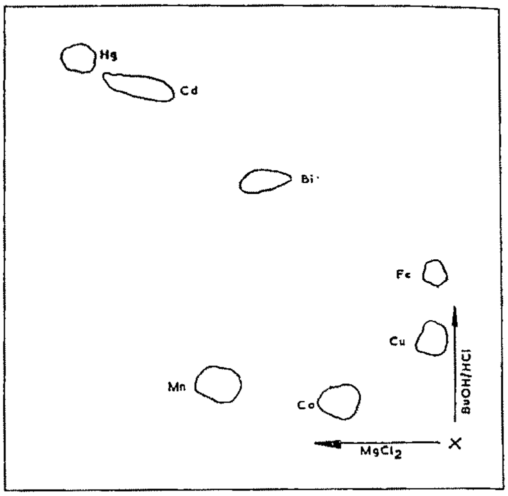

Fig. 2

14-in. square sheet of paper. The organic phase of a mixture of butanol saturated with 2 *N* hydrochloric acid was used as first solvent in a downward direction, after which the sheet was dried over ammonia to neutralize excess acid and convert the paper to its original form. The second development, in a downward direction at right angles to the first development, was with *N* magnesium chloride solution. The choice of this eluting agent stems from its successful application by other workers^2. The separated spots were detected by spraying with a pentacyanoammino-ferrate/rubeanic acid complex, which produces characteristic colours with a large range of cations^3.

Fig. 1 is a map of the spots on the completed chromatogram. The position of the spots in the first direction is similar to the positions expected on unmodified cellulose. Iron occupies an anomalous position possibly due to complex formation between it and the phosphate groups on the paper^4. The flat shape of the cadmium spot in the magnesium chloride direction is probably due to the occurrence of a magnesium – ammonium boundary at this point.

(2) Carboxylated cellulose (type 2) containing primary carboxyl groups was used in its hydrogen form. A mixture of copper, manganese, cobalt, cadmium, bismuth, iron and mercury was applied as a spot near one corner of a 14-in. square sheet of paper. Development was carried out in two directions, using the same solvents and technique as in (1).

Fig. 2 is a map of the spots on the completed chromatogram. In the first direction, iron has assumed a more typical position, but in the magnesium chloride direction the position of bismuth is not that expected of a trivalent ion.

(3) Aminated cellulose containing aminoethyl groups was used in the form of its hydrochloride. A mixture of copper, cadmium, lead, bismuth and mercury was applied as a spot near one corner of a 14-in. square sheet of paper. The first solvent was a butanol–2 *N* hydrochloric acid mixture as before. After drying at room temperature, without addition of ammonia, the chromatogram was developed in the second direction with *N* hydrochloric acid^2. The positions of the spots were revealed by spraying with ammonium sulphide solution.

Fig. 3 is a map of the spots on the completed chromatogram. R_F values in the first direction are lower than in 1 and 2 and it is tempting, from the position of the spots, to assume a mechanism largely of partition type with the lower R_F values being due to the increased polarity of the cellulose. However,

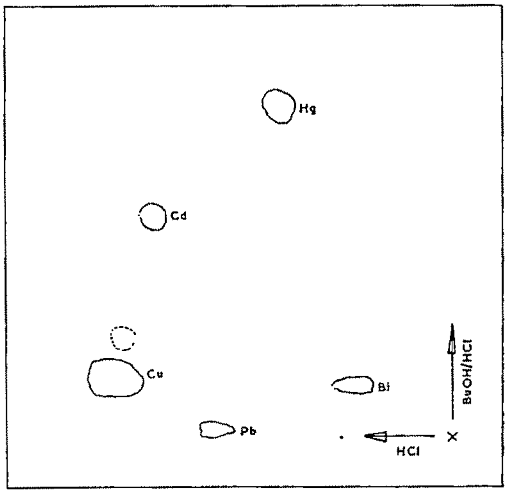

Fig. 3

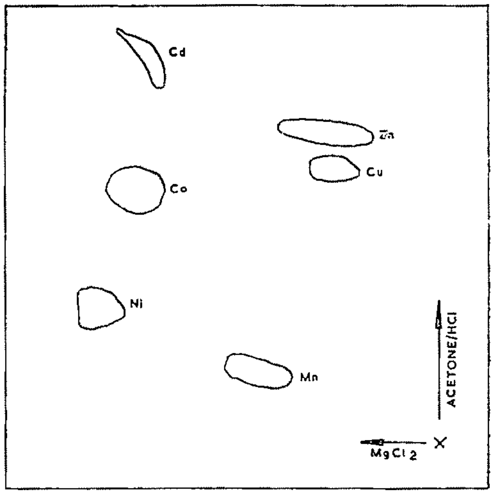

Fig. 4

in this particular case where the ionization of the functional groups is not suppressed it is possible that the mechanism is of a more complicated nature. The metals separate as their anionic complex chlorides in the second direction. The spot represented by the dotted outline was due to a trace of iron in the original mixture.

Slight variation of the relative positions of the various cations on the different materials in the butanol–hydrochloric acid direction is to be expected, the weak carboxyl exchanger giving a separation closest to that obtainable on unmodified cellulose. From Figs. 1, 2, and 3, however, it can be seen that good separations can be obtained on relatively small areas of paper. Fig. 4, for example, illustrates a separation of six metals on an 8-in. square of phosphorylated paper by an ascending technique, using an acetone–hydrochloric acid–water (50 : 5 : 5) mixture in the first direction and *N* magnesium chloride in the second.

The advantages of the increased separation by the above method will be emphasized in the separation of a series of related substances where it is common in conventional two-dimensional paper chromatography to obtain separations in which the majority of the spots are concentrated in one diagonal half of the paper, since in many cases the relative R_F values of the series of substances are similar in a whole range of different organic solvents.

To sum up, therefore, compared with the conventional two-dimensional chromatogram, the method described above, by virtue of the incorporated ion-exchange characteristics, provides an overall increase in separability, speed and reproducibility.

This method is being applied to amino-acid separations with promising results. Details of this, together with a fuller report on the inorganic separations, will be published later.

I wish to thank the Directors of W. and R. Balston, Ltd., for permission to publish this work.

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NATURE OF THE VIBRATO AND THE CONTROL LOOP IN SINGING

By Dr. J. A. DEUTSCH and J. K. CLARKSON
Institute of Experimental Psychology, University of Oxford

ANY attempt to analyse the control mechanisms in the human operator is greatly facilitated if we can control all the information which is fed from the output back into the input. But whereas in most skills proprioception, which is resistant to such control, is of importance, in singing the role of the auditory pathway is paramount. This can readily be heard if a subject is asked to sing a simple musical scale when a strong masking noise obliterates his hearing of his own performance. He will sing badly out of tune.

As a result, the investigation into the control mechanisms of skill has shed some light on the cause of fluctuations in frequency in the singing human voice. It has long been known that when a subject attempts to sing a steady note there is a periodic fluctuation in frequency of approximately 5–6 cycles per second. Suspecting that this tremor might represent the oscillations due to a control mechanism utilizing auditory feedback, the senior author began a series of experiments, now concluded by both of us, which show that this supposition is at least partially the case.

We find that if a delay is interposed between the subject's singing a note and afterwards hearing it, the time taken for one cycle of fluctuation increases directly with the interval of incorporated delay, and that the same is true of the amplitude of the deviation from the note he is attempting to sing. These points are illustrated in Figs. 1 and 2, respectively. Records of the frequency fluctuations were obtained through an audio-frequency meter devised by the senior author[1]. Samples of these records with no artificial delay and with 0·366 sec. delay are shown in Fig. 3. The voice was delayed by the procedure of recording on tape at one point and taking off at an adjacent point through another lead. The output was then greatly amplified and fed back to the subject through a pair of earphones. The loudness of the note fed back in this way was sufficient to mask the sound of the subject's own undelayed voice.

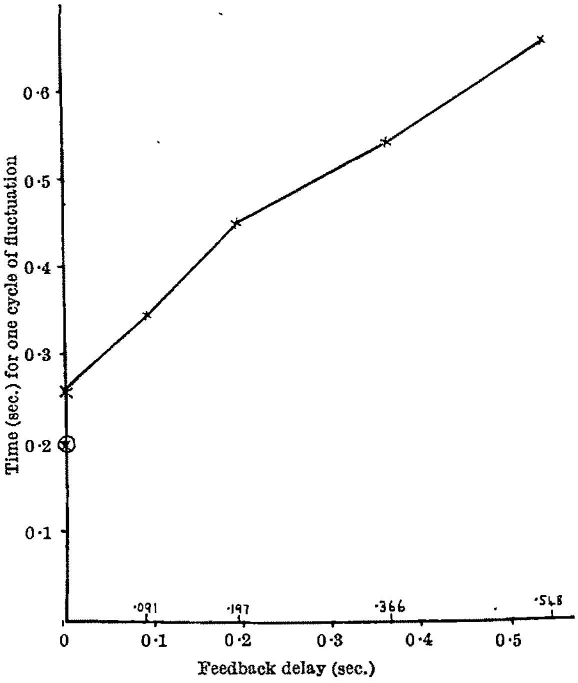

Fig. 1. Average time taken for one cycle of fluctuation under varying feedback delays. Each point represents an average for thirteen subjects. The encircled point on the abscissa gives the average time for the normal voice. The first point of the graph gives the average for monitoring through earphones without an incorporated delay

The importance of the findings is as follows.

The voice is largely controlled by the auditory message generated by it (this probably only applies to the fine frequency control of the voice, for at very long delays the deviations from the desired note do not reach the amplitude predicted on this mechanism alone).

The control does not seem to be applied in proportion to the magnitude of the error as the correction made in response to the error continues smoothly until it has led the subject into an error of opposite sign which is of equal amplitude. Further experiments to check this view have already been undertaken with an artificial larynx where the amount of change perceived by the subject can be instantaneously exaggerated to him. Using this type of apparatus, if we invert the direction of change it should be possible to discover whether the sign as well as the magnitude of error is disregarded by the mechanism determining the corrective movements. We should then be able to speculate more accurately about the mechanisms of skilled performance generally.

It appears that the time taken to react to an error in this kind of skilled performance is rather lower than might have been suspected from the existing data on reaction times and refractoriness. It must be remembered that a subject can only start reacting to his own error when the note produced by the error has exceeded the difference threshold between itself and the note he is aiming to sing. From the records which we have obtained of the subject monitoring his own performance without the intermediacy of headphones (that is, in the natural way) we conclude that the subject's reaction time is 0·10 sec., even if we credit him with an ability to discriminate infinitely small variations in pitch, but of course even this very low figure should be substantially smaller. It is to be noted that the period of oscillation increases when the subject is monitoring himself through earphones, utilizing a note which has been instantaneously amplified. This we take to be due to an increase in the differential threshold in pitch in the monitoring process when the subject is presented with a sound less familiar to him than the sound of his natural voice. (This observation tends further to substantiate our claim that in the frequency vibrato we are dealing with a phenomenon of auditory feedback control.) The mean auditory reaction usually quoted[2] is 0·15 sec. Such a time increases in the ordinary situation if the signals follow close on each other, as has been shown by R. Davis[3], following the work of Craik and Welford on serial reaction times. However, the corrections we note are often obscured by a higher-frequency tremor, and this will make our estimate inaccurate.

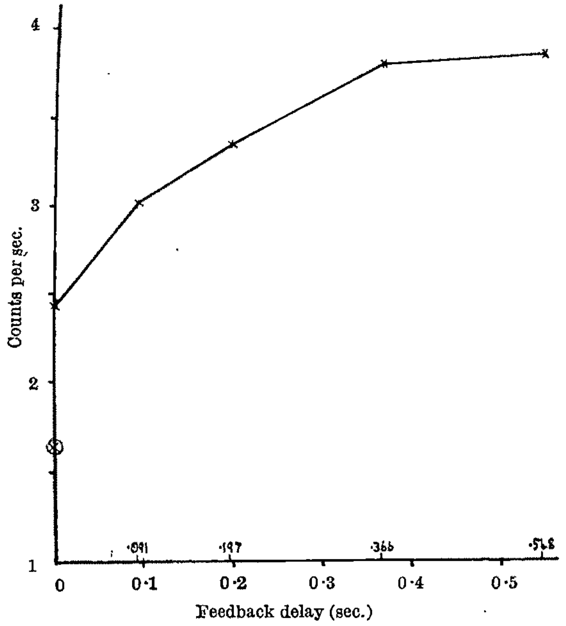

Fig. 2. Average amplitude in cycles of frequency fluctuation under varying conditions of delay. The encircled point on the abscissa gives the average for the normal voice. The first point of the graph gives the average for monitoring through earphones without an incorporated delay. (All points give averages for thirteen subjects)

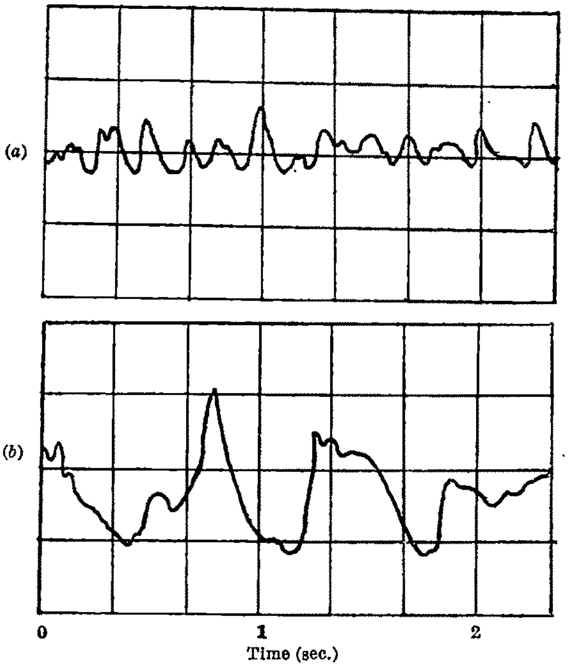

Fig. 3. (a) Frequency fluctuations of normal voice singing a note of 180 c./s.; (b) fluctuations of same voice with feedback delay of 0·366 sec. (It can be seen that in both records there are superimposed higher-frequency tremors of unknown origin)

It also appears that the corrections are made to differences in pitch which would, from the results of the usual experiments, be below the threshold of discrimination. It is hoped that with the method of the artificial larynx outlined above it may be possible to determine more precisely both the size of reaction time to a signal in this situation and the amount of frequency change necessary to trigger off such a control movement. At present we can only say that the corrective movement occurs when the deviation has reached only a matter of 1·6 c./s. when singing a 120 c./s. note under normal conditions. This fixes the largest possible threshold if we assume that the reaction time is vanishingly small. Both the small reaction time and threshold may be due to the high probabilities of the signal and this requires to be investigated further.

We are indebted to the Medical Research Council for grants in aid for apparatus and a grant for scientific assistance.

We should also like to thank Prof. R. C. Oldfield for the encouragement he has given us and for the facilities he has granted us in his laboratory.

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It may be noted that for ages as great as those of the meteorites, ~$4 \cdot 5 \times 10^9$ years, there is a more noticeable discrepancy between α- and β-ages. Thus for the case of the meteorites there may be a better chance to confirm or reject the hypothesis of a varying weak interaction constant. Unfortunately, because of the discordance between lead–lead[8] and uranium–lead[9] ages of meteorites, there is reasonable doubt about the accuracy of the ages based on lead ratios. Also, because of the spread in ages obtained from the potassium-40–argon-40 method[10,11], there is reason for believing that some argon has been lost. This throws this determination somewhat in doubt. The strontium-87–rubidium-87 determinations[12] are few and may not have the necessary reliability.

It is concluded that there is no present evidence sufficiently reliable to rule out a variation with time in the β-decay rate.

This work was supported by the U.S. Atomic Energy Commission, the Office of Naval Research and the Higgins Scientific Trust Fund.

R. H. DICKE

Palmer Physical Laboratory,
Princeton University.
Nov. 19.

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The De Haas–Van Alphen Effect in Copper

THE de Haas – van Alphen effect in copper has been observed in a whisker made by the Brenner method[1] and oriented with the [111] axis along the field (see Fig. 1); the period is about $1 \cdot 7 \times 10^{-9}$ gauss^{-1}, which is close to the value for a free electron sphere of one electron/atom and not inconsistent with the Fermi surface proposed by Pippard[2]; the effective electron mass as estimated from the temperature variation of the effect is about 1·3 times the free electron mass.

Previous negative results[3,4] may have been due to (*a*) crystal imperfections, (*b*) eddy currents associated with the impulsive field, (*c*) non-occurrence of the effect in certain crystal directions. Copper whiskers are usually very well oriented along one of the principal crystal directions and are of good quality as crystals; thus they are particularly favourable as regards (*a*), since the influence of a given degree of imperfection is least along a direction of symmetry. Moreover, a whisker provides in a natural way a very thin crystal wire and thus helps as regards (*b*); the diameter of the whisker used was about 0·2 mm. It is interesting to note that three other whiskers, two oriented along [100] and one along [110], showed no de Haas – van Alphen effect; this may well be merely because of inadequate sensitivity (in the successful observation the oscillations had only about ten times the noise amplitude), but it is possible that the magneto-resistance effect is particularly high for the [111] direction[5–7] and not for the other directions, thus making the [111] whisker particularly favourable as regards reducing eddy currents.

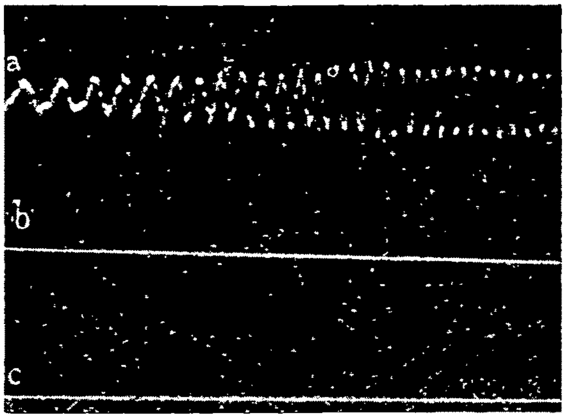

Fig. 1. Trace *a* shows the amplified output from a pick-up coil containing the [111] whisker at 1·1° K. in a magnetic field H of about 72,000 gauss, which drops by about 250 gauss across the picture during a time of sweep of about 0·6 msec. This drop is indicated by the slight decrease of separation between traces *b* and *c*, which is a measure of the variation of $(H - 67{,}000)$ gauss. The shortening of the interval occupied by each successive period is due to the increasing rate of decrease of the magnetic field from left to right

The discovery of a positive effect in copper removes the suspicion that the earlier negative results in monovalent metals may have been due to fundamental rather than technical reasons, and thus opens the way to a detailed investigation of the electronic structure of these metals.

It is a pleasure to acknowledge the hospitality of the General Electric Research Laboratory, Schenectady, N.Y., during last September, which provided the opportunity of obtaining the whiskers, and I should like particularly to thank Mrs. Ethel Fontanella, of General Electric, for her assistance in preparing the whiskers for use, and Mr. Harry Davies for his assistance in the experiments.

D. SHOENBERG

Royal Society Mond Laboratory,
University of Cambridge.
Dec. 22.

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Crystal Structure of Foshagite ($Ca_4Si_3O_9(OH)_2$)

WE have recently made some predictions about the crystal structure of foshagite, based on a study of the dehydration process at 700° C. together with electron diffraction and X-ray fibre evidence[1]. There were strong indications that the structure consists of calcium and hydroxyl ions, and metasilicate chains resembling those in wollastonite[2], and the approximate positions of the calcium ions were suggested. A complete trial structure is now postulated, and more detailed consideration of the X-ray evidence shows that it is essentially correct.

The structure is shown in Fig. 1 with that of parawollastonite (monoclinic β-monocalcium silicate) for

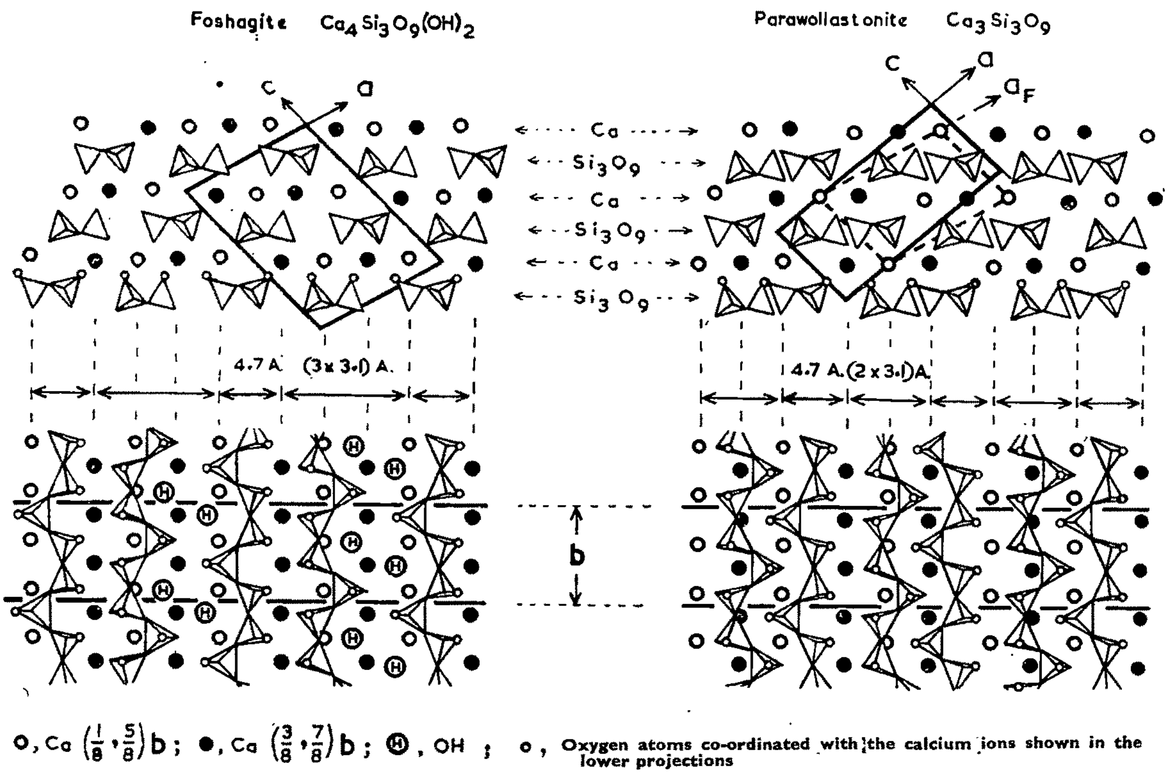
Foshagite $Ca_4Si_3O_9(OH)_2$
Parawollastonite $Ca_3Si_3O_9$
c
a
a_F
Ca
Si_3O_9
Ca
Si_3O_9
Ca
Si_3O_9
4·7 A. (3 x 3·1) A.
4·7 A. (2 x 3·1) A.
b
O, Ca $(\frac{1}{8}, \frac{5}{8})$b; ●, Ca $(\frac{3}{8}, \frac{7}{8})$b; Ⓗ, OH ; o, Oxygen atoms co-ordinated with the calcium ions shown in the lower projections

Fig. 1. Projections of the structures of foshagite and parawollastonite. Full lines define unit cells. Broken lines in figure for parawollastonite outline pseudo-cell of foshagite, showing how the calcium positions are related in the two structures

comparison. As previously suggested, the positions of many of the calcium ions, and also those of many of the oxygens, are nearly the same in the two structures, but there are fewer metasilicate chains in foshagite, the excess charge being balanced by hydroxyl. In both cases, the calcium ions lie in distinct planes (201 for parawollastonite and 102 for foshagite). Within these planes, they occur in rows parallel to *b*, adjacent rows being separated by either 3·1 or 4·7 A. The 3·1 A. separation is the same as the corresponding one in calcium hydroxide, and each metasilicate chain is kinked so that the oxygens on one side can participate in formation of an octahedral Ca—O sheet resembling that in calcium hydroxide (Fig. 2). In foshagite, some of the oxygen positions are occupied by hydroxyl. On the opposite side of each chain, the oxygens are farther apart in projection, causing the octahedral sheets to be split into bands. These are four calcium ions wide in foshagite and three in β-monocalcium silicate, corresponding to the Ca : Si ratios of 4 : 3 and 3 : 3 respectively.

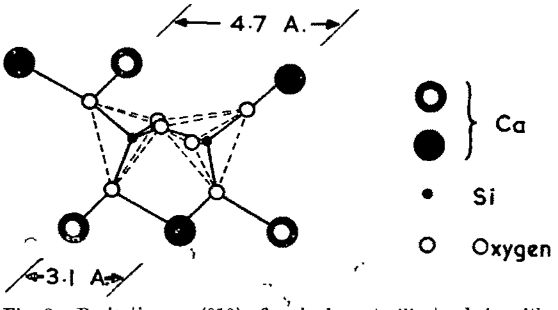

Fig. 2. Projection on (010) of a single metasilicate chain with co-ordinated calcium ions, showing Ca—Ca distances in projection of 3·1 and 4·7 A.

As crystals of foshagite sufficiently large for single-crystal X-ray work are unknown, the structure was tested by comparing calculated structure factors with ones derived from X-ray fibre rotation photographs. The *R*-factor for the first fifty-eight *h0l* reflexions was 0·29, and that for the first thirty-six *h2l* reflexions was also 0·29. In view of the difficulties of measuring the intensities accurately, and also of indexing some of the reflexions, this was considered adequate proof that the structure was basically correct, and refinement will be attempted. No attempt was made to calculate intensities for reflexions with *k* odd, which are extremely weak and streaked because of mistakes of *b*/2 in the positions of the metasilicate chains.

The unit-cell given previously (*a*, 10·32 ; *b*, 7·36 ; *c*, 14·07 A. ; β, 106·4° ; *A*-face centred) is confirmed, but it is only geometrically monoclinic, and the true cell is triclinic with half the volume and space-group $P\bar{1}$. Provisional atomic co-ordinates are given (Table 1) in terms of the *A*-centred cell.

Table 1. PROVISIONAL ATOMIC CO-ORDINATES FOR FOSHAGITE

	x	*y*	*z*
Ca$_{\text{I}}$	0·389	0·125, −0·375	0·300
Ca$_{\text{II}}$	0·164	0·375, −0·125	0·398
Si$_{\text{I}}$	0·306	0·125	0·057
Si$_{\text{II}}$	0·158	0·408, −0·158	0·154
O,OH$_{\text{I}}$	0·447	0·125, −0·375	0·127
O,OH$_{\text{II}}$	0·306	0·125, −0·375	−0·058
O$_{\text{III}}$	0·234	0·375, −0·125	0·264
O$_{\text{IV}}$	−0·006	0·375, −0·125	0·128
O$_{\text{V}}$	0·228	0·306, −0·056	0·079
O$_{\text{VI}}$	0·172	−0·375	0·134

The relation of foshagite to β-monocalcium silicate is somewhat analogous to that of members of the chondrodite series to olivine; the two minerals could be regarded as the first two members of a series with general formula $Ca_{3+n}Si_3O_9(OH)_{2n}$. It is structurally possible that more basic members of this series may exist and hillebrandite ($2CaO.SiO_2.H_2O$) may be the member with $n = 3$; this hypothesis is being investigated. The crystal structure of foshagite was briefly described at the symposium on "Kristallchemie und Strukturanalyse", Berlin, March 1958, and a full account will later be published elsewhere.

J. A. Gard
H. F. W. Taylor

Department of Chemistry,
University of Aberdeen.
Oct. 20.

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Electron Affinity of Atomic Lithium

Recent measurements[1] of some atomic electron affinities based on observations of the optical threshold for electron detachment give rise to a need for theoretical calculations of electron affinities for comparison. However, none of the empirical extrapolation methods has a justifiable theoretical basis for the extension from atoms and positive ions with attractive Coulomb fields to negative ions with fields of short range. In the case of H^- the extrapolated value[2] of the electron affinity is in good agreement with the value obtained by quantum-mechanical calculations[3], but in the case of Li^- the question still remains unanswered.

Geltman[4] has used the value electron affinity (Li) = 0·384 eV., obtained by a quadratic extrapolation procedure with spectroscopic data on isoelectronic systems, for the threshold in his theoretical calculations of the continuous absorption coefficients of Li^-. This value does not agree with other estimated values (Ta-You Wu[5], 0·90 eV.; Moiseiwitsch[6], 0·74 eV.; and Holøien[7], 0·75 eV.).

The Ritz variational principle is a method frequently used for determining the electron affinity as the difference in potential energy between the ground-state of the atom and the ground-state of the negative ion. The limit to which a given choice of potential parameters makes the energy converge may be used as a criterion for the reliability of the results obtained.

However, such a calculation minimizing the energy in the Ritz variational procedure is difficult and tedious to carry out when applied to the four-electron Li^- ion, but in view of the facts mentioned above, a variational determination of electron affinity (Li) is very important. Fortunately, much progress is made by using an electronic computer in evaluating the matrix elements and solving the secular equation.

The purpose of this communication is to direct attention to results already obtained by variational calculation of the energy of H^- in the $(2s)^2\,{}^1S$ state using a 20-parameter function[8]. If we neglect in Li^- the inter-shell interaction and consider the K-shell as essentially at the nucleus, the variational procedure is identical with that for the $(2s)^2\,{}^1S$ state of H^-. By using the data quoted in Table 3, ref. 8, for H^-, the electron affinity $E\,(Li \rightarrow Li^-) = 0{\cdot}81$ eV. is obtained in good agreement with the estimated results[5–7] (1 eV. = 8066·0 cm.$^{-1}$). As an interesting comparison the data for helium quoted in the same table give $E(Be^+ \rightarrow Be) = 8{\cdot}12$ eV. (the observed value is 8·89 eV.).

Of course, when taking into account the repulsion of electrons with parallel spin by the penetration of the L-electrons into the charge distribution due to the K-electrons, the above electron affinity will be reduced; but by how much? It is hoped that a variational calculation applied to the ground-state of Li^- by using a 20 × 20 matrix built up from the same configurations for the L-electrons as in ref. 8 will answer this question. Further work along these lines is now in progress.

E. Holøien

Institute of Theoretical Physics,
University of Oslo.
Nov. 14.

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Improvement in the Magnetic Detecting Power of Iron-cored Search Coils

Slowly changing magnetic fields have usually been measured by means of search coils with iron or mumetal cores, connected either to fluxmeters or to galvanometers. In this communication the term 'coiled rod' is employed and means a straight ferromagnetic rod about which a detector-coil is wound. The sensitivity or detecting power of the coiled rod is usually defined as the total number of flux linkages of the winding produced in the coiled rod by a spatially uniform magnetic field of one oersted and is measured in Maxwell-turns per oersted. The advantage of mumetal over iron for the core of the coiled rod has been its high permeability in low magnetic fields, low electrical losses and low coercive force. Any further increase in sensitivity of coiled rods has been obtained either by lengthening the rod and so reducing its demagnetizing factor or by winding on more turns—the latter case being accompanied by a rapid increase in inductance and by increased resistance unless the diameter of the wire in the coil is correspondingly increased, which in turn affects the overall diameter.

It has been found that a very useful increase in sensitivity of a given coiled rod can be obtained by fitting permeable collector cones to the ends of the rod, the vertices of the cones facing towards the centre of the rod. So far as the experiments have proceeded, an eight-fold increase in sensitivity may be obtained. The increase in detecting power appears to be almost linear with diameter of cone up to the largest tested (1·5 times the length of the rod), the detecting power being increased by a factor K:

$$K = \left(1 + n\frac{D}{l}\right)$$

where n is about 6 for cone diameters (D) less than half the length (l) of the rod, and 5 for larger cones. A good working approximation for the whole range of D up to 1·5 l (and perhaps beyond) being:

$$K = \left(1 + 5{\cdot}4\frac{D}{l}\right)$$

It also appears that this increase in detecting power is accompanied by only a small increase in inductance, for example, in one case where K (detecting power) equalled 2·10, the corresponding inductance factor K_L was only 1·3. (K_L is defined similarly to K, that is, the ratio of the inductance of the coiled rod with collector cones to the inductance without cones.)

The expression above applies to coiled rods in which a uniform winding covers most (90 per cent) of the length of the rod; smaller increases only would be achieved where concentrated or asymmetric windings are employed, since it is known that fittings to the end of the rod affect the central flux in the rod to a much smaller extent than the flux towards the ends—they cause a more uniform distribution of flux over the whole length of the rod.

Cones have been used on mumetal rods of relatively large size (⅜ in. and greater diameters and a wide variety of lengths) and the axial depth of the cone has been arbitrarily fixed at 1 in. in order to provide a suitable fitting to the rod: each end of the rod fits into a recess in the cone and is rigidly secured by a steel screw. A typical design is illustrated in Fig. 1, in which the left-hand cone is shown withdrawn from the drilled and threaded rod-end. The material for the cones found most satisfactory has been machined mild steel, but cast steel has been successfully used in one case. Solid cones in the larger sizes cause a significant increase in the weight of the assembly; but hollow cones in various forms have been found to be useless as intensifiers. No investigation has been made on miniature coiled rods, where rod diameters may be ⅛ in. downwards to small-wire or rolled-strip sizes, to determine the corresponding practical axial depth of the cone for satisfactory use with such small detectors.

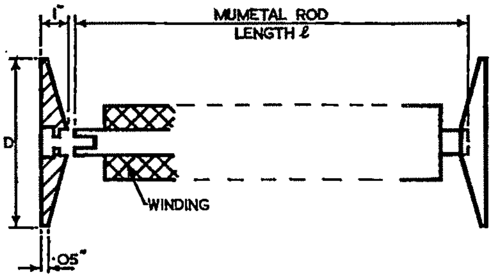


Fig. 1. Typical arrangement of mild steel collector cones on a coiled rod

Collector cones may be most useful where axial length of the coiled rod is restricted; where the weight, cost or resistance of the copper coils must be kept down but where the overall diameter is less important; or where cones of a diameter equal to or exceeding the length of rod may be employed. Where alternating magnetic fields are to be measured, precautions will have to be taken against losses due to eddy-currents in the cone as well as in the material of the rod. It would be interesting to investigate whether cones, in a suitable permeable material of high specific resistance, could be used with similar success in fluxgate detectors as intensifiers, since it is expected that an improvement in output signal voltage may be obtained similar to that described above for induction systems.

The mechanism of the increase is not fully understood. Since the distribution of flux along the rod is more uniform when cones are fitted, it may be deduced that the effect is caused by the spreading of the demagnetizing poles outwards from the ends of the rod on to the outside face of the cones. There is some evidence, however, that the magnetic field in part of the annular space between the cones but outside the rod (that is, the space occupied by the copper coils) is higher than the external field to be measured. This suggests that part of the function of the cones is to enhance the external field between them.

D. F. WALKER

5 Auriol Drive,
Bedhampton,
Hampshire.
Oct. 8.

Effect of Humidity on the Spark Breakdown Voltage

THE influence of water vapour on the breakdown voltage of uniform field gaps has been investigated by Ritz[1]. He found that the breakdown voltage of a 1-cm. uniform field gap at 760 mm. mercury pressure in air increased by 2 per cent for a change in the partial pressure of water vapour from 10 to 25 mm. mercury. More recently, Köhrmann[2] has published results which indicate that the presence of water vapour at 10 mm. mercury raised the breakdown voltage by 2·7 per cent above that of dry air at 760 mm. mercury. Lewis[3] investigated the humidity effect for sphere gaps and quoted an increase of 0·13 per cent in voltage for each mm. mercury of water vapour. This value is rather low compared with the two other results and may be due to the fact that he used a gap of 0·4 cm. between 2-cm. spheres.

A uniform field gap was mounted within a glass cylinder which could be evacuated and gases admitted through a drying system. Water vapour could be added and its partial pressure measured. The d.c.-voltage source was stabilized to better than 1 part in 5,000 per hour. The breakdown voltage was determined by plotting the sparking-rate for a range of voltages above the minimum value and extrapolating the curve to a voltage corresponding to zero sparks per minute. The spark gap was unirradiated since it had been found that irradiation reduced the breakdown voltage of a plane gap by only about 0·1 per cent.

Measurements have been made under the following conditions: (1) plane electrodes, with a Bruce profile, in air at pressures of 760 mm. and 500 mm. mercury with water vapour and for gaps of 1 cm. and 2 cm. respectively; (2) plane electrodes in nitrogen at 760 mm. mercury with a mixture of 2 : 1 ethyl alcohol – water vapour and a 1-cm. gap; (3) spheres of 2-cm. diameter in air at 760 mm. mercury with water vapour and a 1-cm. gap.

The effect of humidity on the breakdown voltage in air and nitrogen is plotted in Fig. 1. The values for 2-cm. spheres appear to fit the same curve as those for plane electrodes. Two points are plotted which were obtained in moist laboratory air. These points also fit the curve reasonably well. Also shown in Fig. 1 are the results for the effect of ethyl alcohol – water vapour on the breakdown in nitrogen. These points lie below the curve for water and air; this is to be expected if the increase in voltage is solely an effect due to the water, since the partial pressure of water in the vapour mixture was 33 per cent of the total pressure of the vapour mixture. The breakdown

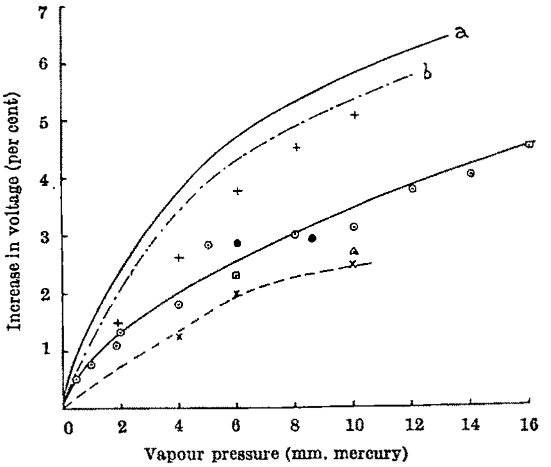
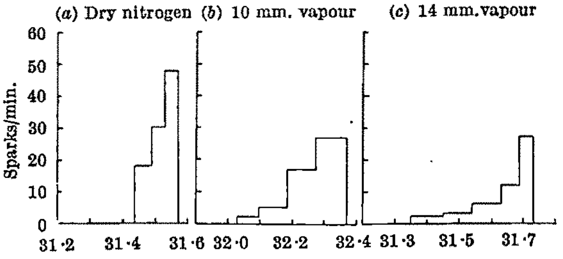


Fig. 1. Effect of vapour on breakdown voltage. (*a*) After Köhrmann (ref. 2) for 2-cm. gap at pressure of 500 mm. mercury; (*b*) calculated from measurements for a 1-cm. gap at 760 mm. mercury; +, air and water vapour, 2-cm. gap between plane electrodes at 500 mm. mercury; ⊙, air and water vapour, plane electrodes, 760 mm. mercury; ●, moist atmospheric air, plane electrodes, 760 mm. mercury; ⊡, air and water vapour, 1-cm. gap between spheres at 760 mm. mercury; △, after Köhrmann (ref. 2), plane electrodes at 760 mm. mercury; ×, nitrogen and ethyl alcohol – water vapour, plane electrodes at 760 mm. mercury

voltage in dry nitrogen was found to be 2·6 per cent higher than in air at 760 mm. mercury and 20° C. This difference could be explained by the lower value of α/p for nitrogen.

Referring to the results of Köhrmann for a 2-cm. gap in air at 500 mm. mercury it was noted that the effect of humidity was greater than for a 1-cm. gap at a pressure of 760 mm. mercury. These results are plotted in Fig. 1. Measurements made by us for a 2-cm. gap at 500 mm. mercury lie slightly below those of Köhrmann. The chain dotted line in Fig. 1 gives the values obtained at 760 mm. mercury for a 1-cm. gap normalized to 500 mm. mercury.

It was found that the rate of sparking was also a function of humidity. Several examples are plotted as histograms in Fig. 2 for increasing amounts of ethyl alcohol – water vapour in nitrogen. The rate of sparking for dry nitrogen increased from zero to 48 sparks/min. for a change in voltage of 0·13 kV., whereas with 10 mm. mercury vapour pressure the rate of sparking increased from zero to 25 sparks/min. for a change in voltage of 0·34 kV. When the vapour pressure was 14 mm. mercury the rate of sparking was approximately the same but the threshold voltage for sparking fell to a lower value. This threshold shifted to a higher voltage with continued sparking as shown in Fig. 2(*d*). Histogram (1) shows the first rate of sparking; after 20 min. sparking the histogram (2) shifted to a higher voltage and after 40 min. reached the still higher voltage of histogram (3). It was concluded that when the vapour pressure reached a certain value, condensation occurred on the electrodes and lowered the breakdown voltage. This layer of liquid was removed by sparking and the breakdown voltage then increased. Measurements with spheres showed a rather flat histogram for the rate of sparking, similar to Fig. 2(*d*), and accurate determination of the minimum breakdown voltage was more difficult.



(*d*) 21 mm. vapour

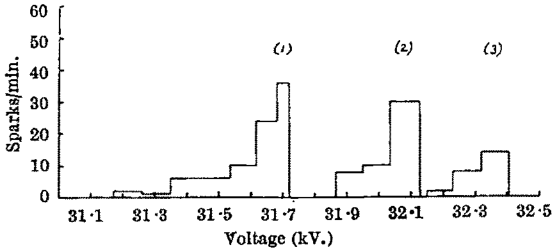


Fig. 2. Histograms of rate of sparking for different amounts of vapour

It may be concluded that the effect of water vapour is to increase the breakdown voltage by 3·5 per cent for 10 mm. mercury partial pressure of water vapour at 760 mm. mercury. The results are in general agreement with those of Köhrmann and Ritz for plane electrodes at 760 mm. mercury pressure in air. It is obviously necessary to correct for humidity when comparing values of breakdown voltage obtained under different conditions.

K. R. ALLEN
K. PHILLIPS

Research Department,
Metropolitan-Vickers Electrical Co., Ltd.
Trafford Park,
Manchester, 17.
Dec. 4.

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CHEMISTRY and GEOCHEMISTRY

Use of Approximate Wave Functions for Extrapolation to True Energy Values

A WAVE equation $H\varphi = E\varphi$ can be written for any trial function φ. Only if φ is equal to an eigenfunction ψ_n, however, does E have a constant value (E_n). In general, for any trial function, φ, there is a corresponding average energy, $E_{av.}$, defined by:

$$E_{av.} = \int\varphi^* H\varphi d\tau \Big/ \int\varphi^*\varphi d\tau$$

The variation principle shows that for the lowest state $E_{av.} \geqslant E_0$, and $E_{av.}$ is thus an upper bound to the true energy, E_0. No means is provided by the variation principle for the extrapolation to E_0 from a series of calculated values of $E_{av.}$

For an approximate function φ, the function $E = H\varphi/\varphi$ fluctuates about the mean value $E_{av.}$ with mean square deviation Δ given by:

$$\int\varphi^*\left(\frac{H\varphi}{\varphi} - E_{av.}\right)^2 \varphi d\tau \geqslant 0$$

Δ becomes equal to zero only when $E_{av.} = E_n$, a true eigenvalue. From a graph of Δ against $E_{av.}$, it might be possible to extrapolate back to $\Delta = 0$, where $E_{av.} = E_n$, and thus provide a useful means of estimating eigenvalues.

Calculations are presented here for two simple systems: (1) a single electron constrained to move in a ring in which the potential energy is a simple one-step function; (2) the helium atom in its ground-state.

(1) *Particle in a ring.* The ground-state eigenfunction is known in this case, and for the two regions of constant potential has the form:

$$a.\ \cos m\theta\left(-\frac{\pi}{6}<\theta<\frac{\pi}{6},\ V=0\right),$$

$$b.\ \cosh m'\theta\left(\frac{\pi}{6}<\theta<\frac{11\pi}{6},\ V=V_0\right)$$

θ being the cyclic co-ordinate. Successive approximations φ_n to the eigenfunction ψ_0 were obtained by taking inclusively the first n terms of the Fourier (cosine) series expansion of ψ_0. The corresponding values of Δ and $E_{av.}$ were readily calculated and are plotted together in Fig. 1.

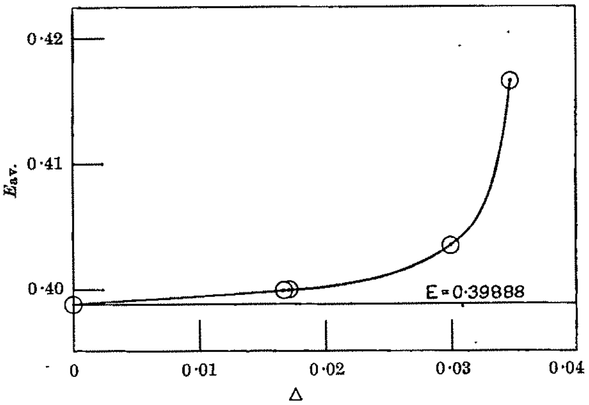

Fig. 1. Graph of $E_{av.}$ against Δ for a particle in a ring; the successive points are for 1-, 2-, 3- and 4-term Fourier (cosine) series. (Arbitrary units)

(2) *Ground-state helium atom.* The true ground-state energy is known spectroscopically. Approximate wave functions of the form (i) $\varphi = u(1)u(2)$, where $u(1)$ represents a hydrogen-like 1*s* function, and (ii) $\varphi = u_1(1)u_2(2) + u_1(2)u_2(1)$, were employed. The effective nuclear charges Z_1 and Z_2 were used as parameters in the usual way and the corresponding values of Δ and $E_{av.}$ calculated. These values are plotted together in Fig. 2.

The general form of the plots of Δ against $E_{av.}$ is similar in the two cases. Apparently, only when $E_{av.}$ is very close to E_0 is Δ likely to vary linearly with $(E_{av.} - E_0)$. Recent very detailed calculations by Kinoshita[1] confirm this. He finds that when $(E_{av.} - E_0)/E_0$ is in the range 0–0·000007, Δ varies linearly with $(E_{av.} - E_0)$.

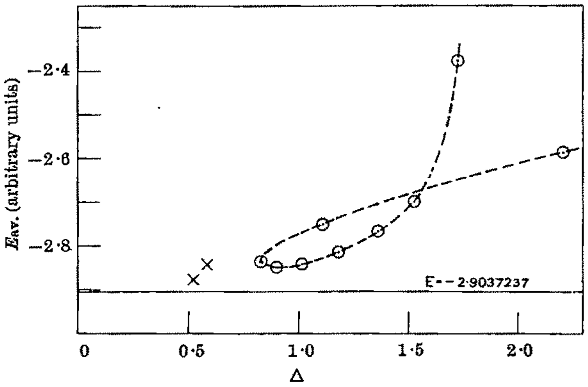

Fig. 2. Graph of $E_{av.}$ against Δ for the helium atom; ○, curve for function (i) with varying Z; ×, for function (ii) with varying Z_1 and Z_2

The wave functions used in the case of helium (ii) are relatively inflexible, and application of the variation method shows that the lowest possible energies for these types of function are bad approximations to E_0. In this case the minimum values of Δ and $E_{av.}$ do not coincide and $E_{av.}$ is not dependent only on Δ.

The construction of a set of trial functions by the inclusion of successive terms of a series expansion, having a complete orthogonal set as basis functions, as in case (i), leads to a single curve of Δ against $E_{av.}$. This type of trial function is to be preferred if Δ and $E_{av.}$ are to provide a useful extrapolation pair.

It appears likely that the inclusion of a not unreasonably large number of terms in such a trial function can enable a fair extrapolation to E_0 to be made.

We wish to thank the Harmsworth Trust of Merton College, the Department of Scientific and Industrial Research and the Gas Council for maintenance grants.

P. G. Dickens
J. W. Linnett
D. Schofield

Inorganic Chemistry Laboratory,
Oxford.

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Determination of the Yields of Molecular Hydrogen Peroxide in the Radiolysis of Water labelled with Oxygen-18

The decomposition of water by the action of ionizing radiations can be represented by the overall expression[1,2]

$$H_2O \rightsquigarrow H,\ OH,\ H_2,\ H_2O_2 \qquad (1)$$

The relative extents of the radical (H, OH) and molecular yields (H_2, H_2O_2) have been determined for a number of radiations of different ionization densities. The molecular hydrogen yield ($G^W{}_{H_2}$) has been measured directly, in the presence of different solutes (for example, bromide, nitrite[3]). On the other hand, the molecular hydrogen peroxide yield ($G^W{}_{H_2O_2}$) in aqueous solutions irradiated in the presence of oxygen can ordinarily be measured only indirectly[4,5]. (G = molecules/100 eV.)

It is clear, however, that it should be possible to determine the yields of molecular hydrogen peroxide directly by using water enriched with $H_2{}^{18}O$. In these circumstances, only hydrogen peroxide which is formed from the isotopically labelled water, according to equation (1), will contain the oxygen isotope. Provided that the hydrogen peroxide thus formed is not decomposed by subsequent reactions, the molecular hydrogen peroxide yield can be obtained by isotopic analysis of the total hydrogen peroxide produced on irradiation. This analysis can be carried out by treatment of the irradiated aqueous solution with permanganate, which is known to liberate molecular oxygen derived solely from the hydrogen peroxide. Table 1 shows some results obtained from aqueous solutions enriched with $H_2{}^{18}O$ for two different solutes, namely, ethanol and lactic acid at *p*H 1·2 (0·1 *N* sulphuric acid) irradiated with cobalt-60 γ-rays and with 200 kV. X-rays. These two particu-

In quartzo-feldspathic compositions the (anhydrous) oxygen/glass-former ratio of 2·0 prohibits certain configurations requiring a higher proportion of oxygen. This constraint is lacking in the case of glasses of basic composition, and for them a wide range of structural alternatives is open, subject to control by the ruling physical conditions.

In substantially anhydrous glassy lavas of calc-alkaline type there is a progressive diminution in the number of glass-forming ions in unit volume with change in composition from dacite to basalt. The hydrated rocks corresponding in composition, but of intrusive origin, show oxygen-packing figures which exceed those of the anhydrous types by an amount that increases with the basicity. This effect (which may exceed 7 per cent) is attributed to the variable co-ordination state of aluminium and ferric iron, and reflects the effect of pressure as well as that of hydration. In any hydrated glass the water will be distributed between the different types of possible configuration in a manner reflecting the history of the glass. Several lines of evidence appear to point to a general tendency for the proportion of loosely bound water to increase with the total water content. Thus, for example, application of the Gladstone and Dale relationship shows an increase in the specific refractivity of water related to the rise in its concentration in the glass.

A full account of this work will be published elsewhere.

E. D. Lacy

Department of Geology,
The University,
Birmingham 15.
Nov. 21.

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BIOCHEMISTRY and PHYSIOLOGY

Possible Role of Water in Collagen Structure

Although several investigations of the infra-red spectrum of collagen in the 2μ region have been reported[1], no comment appears to have been made on the fact that the absorption band at 5,150 cm.$^{-1}$, generally attributed to sorbed water, is dichroic. The extent of this dichroism is shown in Fig. 1 (above), obtained from kangaroo tail tendon in equilibrium with the laboratory atmosphere. In a further spectrum obtained after drying at 100° C. for 3 hr., shown in Fig. 1 (below), the absorption band at 5,150 cm.$^{-1}$ is virtually eliminated, thus confirming its assignment to sorbed water. Subsequent exposure to the laboratory atmosphere restored the dichroic absorption band at 5,150 cm.$^{-1}$.

It is possible that the observed dichroism is spurious in the sense that it is due to form dichroism rather than intrinsic dichroism; but this is unlikely since other fibres such as nylon and silk show no maxima in dichroism at this frequency and α-keratin and feather keratin only very minor maxima. If, as seems to be the case, the dichroism is intrinsic, it follows that hydrated collagen contains a proportion of water molecules which are preferentially oriented with respect to the polypeptide chains.

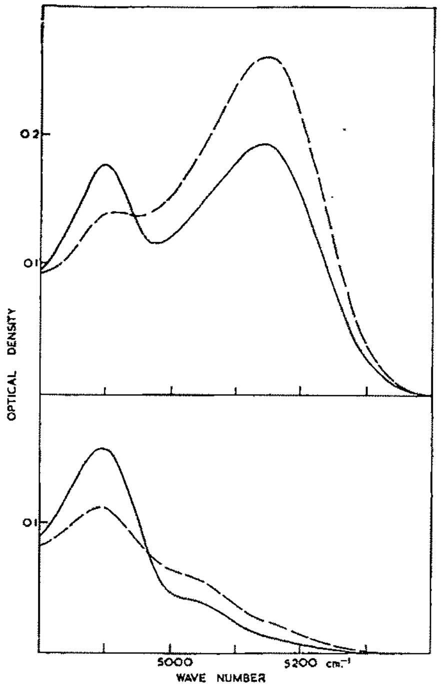

Fig. 1. Infra-red spectra of kangaroo tail tendon. Above, in equilibrium with the laboratory atmosphere; below, dried *in vacuo* at 100° C. for 3 hr. Full line, electric vector vibrating parallel to the tendon axis; broken line, electric vector vibrating perpendicular to the tendon axis

The absorption band at 5,150 cm.$^{-1}$ may be assigned to a combination of the antisymmetrical stretching and symmetrical deformation modes of the water molecule so that the associated transition moment is parallel to the line joining the two hydrogen atoms. The preferred orientation indicated by the perpendicular dichroism is therefore as shown in Fig. 2. From the magnitude of the dichroic ratio it is possible to estimate the minimum fraction of preferentially oriented water molecules[2], and this is found to be 0·18 for the spectrum of Fig. 1 (above).

The configuration of the polypeptide chain in collagen is believed to be such that the CO linkages are approximately normal to the chain axis and that a high proportion project outwards from the triple chain molecule and so are not available for intramolecular hydrogen bonding[3]. It is possible, therefore, that the oriented water molecules are linked to these groups through hydrogen bonds as shown schematically in Fig. 2.

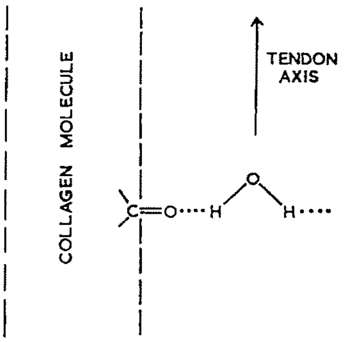

Fig. 2. Preferred orientation for water molecules in tendon deduced from the dichroism of the 5,150-cm.$^{-1}$ absorption band

An unusual feature of collagen is its high proportion of imino-acids, which do not have an N—H bond, and it may be significant that the fraction of oriented molecules calculated above is almost equal to the fraction of the total residues in which there is a CO but no NH bond.

R. D. B. FRASER
T. P. MACRAE

Biochemistry Unit,
Wool Textile Research Laboratories,
Commonwealth Scientific and Industrial
Research Organization,
Parkville, N.2 (Melbourne),
Victoria, Australia.

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Penicillin Derivatives of *p*-Aminobenzylpenicillin

THE formation of *p*-aminobenzylpenicillin was reported by Corse, Jones, Soper, Whitehead and Behrens[1]; but no material was isolated. Brewer and Johnson[2] later obtained partially purified material by using *p*-aminophenylacetic acid as precursor; but no details of yields or purity were given. The work reported here was carried out in order to obtain *p*-aminobenzylpenicillin for use as the parent compound of a series of derivatives. Tosoni, Glass and Goldsmith[3] have since reported the preparation of crystalline *p*-aminobenzylpenicillin by hydrogenation of *p*-nitrobenzylpenicillin and the preparation of certain N-acyl derivatives.

Fermentations were carried out using *Penicillium chrysogenum* 5120*c* (a sub-strain selected from 5120 *Wis*) and a peanut meal/lactose medium. *p*-Aminophenylacetamide was added at the rate of 0·05 per cent every 24 hr. Titres at 96 hr. were 1,000–1,200 μ/ml. by cup-plate assay. Paper chromatography using as solvent the top layer of the mixture butanol–ethanol–water, 40 : 10 : 50, indicated the formation of two principal penicillins and smaller amounts of two others as a result of the addition of the precursor (Fig. 1). The two principal penicillins (zones 3 and 4) were eluted from paper chromatograms and zone 3 identified as *p*-aminobenzylpenicillin. This penicillin was shown to contain a primary aromatic amino-group by diazotization and coupling with resorcinol. After acid hydrolysis, *p*-aminophenylacetic acid was identified on paper chromatograms and also estimated quantitatively. The penicillin from zone 4, on the other hand, although giving *p*-aminophenylacetic acid after acid hydrolysis, could not be diazotized except after acid hydrolysis, suggesting this penicillin to be a substituted *p*-aminobenzylpenicillin. The nature of penicillin 1 and 2 remains unknown.

The *p*-aminobenzylpenicillin was extracted by adjusting the clarified brew to *p*H 6·0 and then percolating through a column of granular charcoal as described by Abraham, Newton and Hale[4]. The column was eluted first with 15 per cent acetone, which removed considerable impurity, followed by 60 per cent acetone, which rapidly eluted all the penicillins. The fraction of this eluate containing penicillin was concentrated to small volume *in vacuo* and 9 vol. of acetone added to precipitate impurities. The supernatant, after centrifuging, was evaporated *in vacuo* to near dryness. This material was then dissolved in the butanol–ethanol–water chromatography solvent described above and chromatographed down a column of powdered cellulose and developed with the same solvent. The penicillins were eluted separately in the order in which they ran on paper strip chromatograms. The eluate fractions containing the *p*-aminobenzylpenicillin were combined and extracted with water, which was then freeze dried. The pale yellow solid obtained assayed at 800 μ/mgm. by cup-plate assay using benzylpenicillin as standard; pure *p*-aminobenzylpenicillin obtained by Tosoni *et al.*[3] assayed at 1,100 μ/ml., indicating the material described here to have been 73 per cent pure. Assay of the latter material by the hydroxylamine method[5] gave a figure of 75 per cent purity.

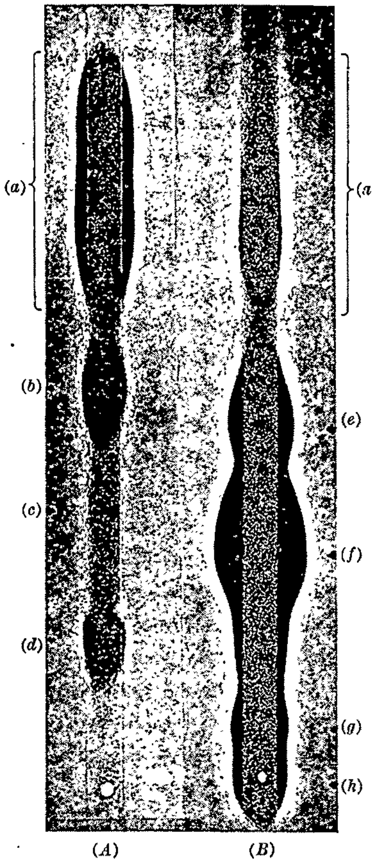

Fig. 1. Paper chromatography of harvest fermentation brew. *A*, No precursor added; *B*, *p*-aminophenylacetamide added, 0·05 per cent every 24 hr. Solvent, butanol–ethanol–water, 40 : 10 : 50, top layer. Chromatograms developed on agar plate seeded with *B. subtilis*. *a*, Penicillins *K*, FH_2, *F*, *G*; *b*, penicillin *X*; *c* and *d*, unidentified penicillin; *e*, penicillin 4; *f*, penicillin 3; *g*, penicillin 2; *h*, penicillin 1.

During the course of the extraction a white crystalline solid separated out on cooling, which, after recrystallization, was identified as the monohydrate of *p*-acetamidophenylacetamide (by elementary analysis and mixed m.p. with an authentic specimen prepared by acetylation of *p*-aminophenylacetamide). The formation of this material during the fermentation suggested that penicillin 4, which appeared to be a substituted *p*-aminobenzylpenicillin, might be *p*-acetamidobenzylpenicillin. Comparison of this penicillin 4 with an authentic preparation of *p*-acetamidobenzylpenicillin prepared from the *p*-aminobenzylpenicillin showed them to be indistinguishable on paper chromatograms and in respect of their antibacterial spectra.

The *p*-aminobenzylpenicillin has been converted into a series of N-derivatives[6] by treatment with reactive halogen compounds such as carboxylic acid halides, 2 : 4-dinitrofluorobenzene and *p*-toluenesulphonyl chloride, following the method of Newton and Abraham[7] for the preparation of derivatives of cephalosporin N. It is hoped to publish further details of these experiments, together with the results of the antibacterial activity of the derivatives, elsewhere, at a later date.

A. Ballio
E. B. Chain
F. Dentice di Accadia

International Centre for Chemical Microbiology,
Istituto Superiore di Sanita,
Rome.

G. N. Rolinson
F. R. Batchelor

Beecham Research Laboratories Limited,
Brockham Park,
Betchworth,
Surrey.
Dec. 4.

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Nucleotide Metabolism in Cardiac Activity

In a previous study on the nucleotide metabolism of cardiac muscle[1], the changes of adenosine triphosphate were investigated during systole and diastole. Using the Cohn and Carter method of analysis[2] on a 'Dowex-1' column, the nucleotides were separated and determined quantitatively by ultra-violet absorption spectrophotometry. During the studies on the extracts of hearts frozen in systole by an acetone–dry ice mixture, a substance appeared as a new peak in the chromatogram, which seemed to be an adenine nucleotide with more nitrogens than could be accounted for. This was called nucleotide *H*.

In spite of the recent results obtained by Mommaerts[3] and Fleckenstein *et al.*[4] it was decided to re-investigate this problem, with special emphasis on nucleotide *H*.

Hearts of dogs were excised rapidly and dropped either into cold isotonic potassium chloride to stop them in diastole, or into liquid air to freeze them in systole. The hearts were then rapidly homogenized in a Waring blendor with 2·5 vol. 0·5 *N* perchloric acid, centrifuged, and the supernate neutralized to *p*H 8 with potassium hydroxide. In all these steps, the temperature was kept below 5° C. After removing the potassium perchlorate by filtration, an aliquot corresponding to about 4 gm. of the original muscle was placed on a 'Dowex-1' column in the chloride cycle, with a bed volume of either 5 or 7 ml. Elution was carried out according to Cohn and Carter[2] except that 0·005 *N*, instead of 0·003 *N*, hydrochloric acid was used, and this was used as the first eluant.

With this system, the results previously obtained[1] were verified. With 0·005 *N* hydrochloric as eluant, adenine was eluted at 2–4 bed volumes and inosinic acid at 15–17 bed volumes. A long trailing peak was eluted at about 50–100 bed volumes, and this was identified as adenosine diphosphate. Usually, elution was stopped after 40 bed volumes of 0·005 *N* hydrochloric acid and the next eluant started. In diastolic hearts no further peaks were obtained with the first eluant; but in systolic hearts another peak came off the column at 22–27 bed volumes, which corresponded to the previously identified nucleotide *H*. This fraction was collected, neutralized to *p*H 7, and concentrated *in vacuo* at a temperature below 50° C. On phosphorus analysis[5], one organic and usually one inorganic phosphorus were obtained per mole adenine, determined spectrophotometrically. Occasionally more than one inorganic phosphorus was obtained. On paper chromatography, using Hanes and Isherwood's[6] method to determine the phosphorus spots, and Magasanik's[7] method to determine the purine spots, a phosphorus spot was always associated with the purine spot, at an R_F value that corresponded to adenylic acid. On mixing some of the unknown with authentic adenylic acid, the purine spots could not be separated on paper.

Furthermore, on paper chromatography there were always two ninhydrin spots identified as aspartic and glutamic acids, with occasionally a third one identified as alanine. Again, on mixing the unknown with authentic glutamic and aspartic acids, no separation occurred on paper.

On rechromatography on 'Dowex-1', or following the precipitation of the nucleotides with mercuric acetate[8], the two amino-acids and the adenylic acid spots were always present, and yet they never chromatographed as one unit on paper. Using the solvent system, *iso*butyric acid/ammonia/water, 66 : 1 : 33, the R_F value for nucleotide *H* was 0·51, adenylic acid 0·51, glutamic acid 0·45, and aspartic acid 0·35. A mixture of adenylic, aspartic and glutamic acids acted in all respects like nucleotide *H*.

Thus, in conclusion, the previously named nucleotide *H* is only an artefact made up of adenylic, aspartic and glutamic acids. On the anion exchange resin, 'Dowex-1', it happened that these three compounds are eluted from the column at the same rate, and are precipitated together by mercuric acetate.

The reason why the two amino-acids appear only in systolic hearts remains to be investigated.

Philip A. Khairallah*

Department of Biochemistry,
American University of Beirut,
Beirut.
Oct. 23.

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* Present address: Cleveland Clinic, 2020 East 93rd Street, Cleveland 6, Ohio. Research Fellow, American Heart Association.

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Biochemical Differentiation of Group *A* and 'Human *C*' *Streptococci*

MOST *Streptococci* are satisfactorily differentiated by relatively simple biochemical methods. Among the exceptions are *Streptococcus pyogenes* (group *A*) and the 'Human *C*' *Streptococcus* (group *C*), which are differentiated with reliability only by Lancefield's serological technique[1]. Wilson and Rosenblum[2] showed that 477 cultures of *S. pyogenes* failed to multiply in raw milk sterilized with ethylene oxide while 31 cultures of group *C Streptococci*, of which at least 11 were 'Human *C*', always grew well in this medium. Recently, Levinson and Frank[3] have published a method utilizing bacitracin for the differentiation of group *A Streptococci*. Approximately 10 per cent of their 67 group *C* strains were not differentiated. They mention the possibility of resistant group *A* strains emerging as a result of the clinical use of bacitracin. Since *S. pyogenes* and 'Human *C*' *Streptococci* are not readily distinguished biochemically by any single test or combinations of such tests[1,4] in present use, a medium and method of differentiating them are of interest.

A medium for this purpose is prepared as follows. 5 ml. of commercial rennet extract is added to 1 litre of fresh, antibiotic-free, raw milk tempered to 40° C. The resulting curd is cut into cubes, and the whey is strained through a cheese-cloth, after which it is centrifuged for a few minutes. Clear whey is removed from the sediment and milk-fat with an aspirator and filtered twice through Whatman No. 42 filter paper, then through a Selas 02 bacteriological filter candle previously autoclaved after being charged with 0·1 *N* hydrochloric acid. The sterile medium is dispensed into sterile test-tubes and incubated for 24 hr. at 37° C. as a sterility check. Tubes showing turbidity are discarded.

Several precautions must be observed in the preparation and care of the test medium. The milk must be raw (unheated) as *S. pyogenes* is able to multiply in heated milk. The raw milk must be free from antibiotics as residual antibiotic resulting from mastitis therapy prevents the growth of 'Human *C*' *Streptococci* in milk. Incubation of the test medium after sterilization is necessary since results are based on turbidity. Prepared medium should be stored in the dark since it is known that exposure to light for extended periods of time eventually allows a slight growth of *S. pyogenes* in raw milk serum. It is necessary to filter the medium twice through filter paper before sterilization or the medium will plug the filter candle before any quantity is obtained.

To differentiate between cultures of *S. pyogenes* and 'Human *C*' a loopful of culture is inoculated into tubes of the sterile, raw milk serum medium. The tubes are incubated for 24 hr. at 37° C. Growth, as shown by turbidity, indicates the presence of 'Human *C*' *Streptococci*. Lack of growth (no turbidity) indicates the presence of *S. pyogenes*.

Nine cultures[5], six of *S. pyogenes* and three of 'Human *C*' *Streptococci*, were grown in meat-infusion broth. They were transferred daily for several weeks and then kept one month in broth without transfer. For the remainder of the test period of six months these cultures were transferred weekly, except for the last week, when they were again transferred daily. The six strains of *S. pyogenes* never multiplied in the raw milk serum medium, as shown in Table 1. This was true when the cultures were young (18 hr.), old (1 month), and transferred daily, weekly or sporadically. The 'Human *C*' cultures always grew in the test medium under the same conditions, attaining counts of greater than 200 million per ml.

Table 1. THE GROWTH OF *Streptococcus pyogenes* AND 'HUMAN *C*' STREPTOCOCCI SUBCULTURED PERIODICALLY IN RAW MILK SERUM MEDIUM

Culture number and group		Subcultured									
		Daily 1	Daily 2	Weekly 1	Weekly 2	Monthly 1	Monthly 2	Monthly 3	Sporadically 1	Sporadically 2	Sporadically 3
*C*203*S*	(*A*)	–	–	–	–	–	–	–	–	–	–
*A*4	(*A*)	–	–	–	–	–	–	–	–	–	–
*A*6	(*A*)	–	–	–	–	–	–	–	–	–	–
*A*8	(*A*)	–	–	–	–	–	–	–	–	–	–
*A*9	(*A*)	–	–	–	–	–	–	–	–	–	–
*A*11	(*A*)	–	–	–	–	–	–	–	–	–	–
*C*519	(*C*)	+	+	+	+	+	+	+	+	+	+
*C*556	(*C*)	+	+	+	+	+	+	+	+	+	+
7078	(*C*)	+	+	+	+	+	+	+	+	+	+

–, No growth. +, Profuse growth.

Others[2] have shown that the property of growth or lack of growth in the raw milk serum medium characterizes many more strains of *S. pyogenes* and 'Human *C*' *Streptococci* than the nine reported here. The procedure previously used required a streak plate after culture in the differentiating medium because of the opacity of the differentiating medium. The medium described here was prepared in the course of another investigation[6] and the necessary testing of a large number of cultures was not possible. It is felt that the simplicity of the turbidimetric method and its potential value in the biochemical scheme of differentiation of *Streptococci* justify a report based on a limited number of cultures.

R. W. HENNINGSON*

Department of Dairy Industry,
Cornell University,
Ithaca, New York.

Oct 24.

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* Present address: Dairy Department, Clemson College, Clemson, S.C.

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Effect of Insulin and Phenazine Methosulphate on Pathways of Glucose Catabolism in the Mammary Gland of the Rat

THERE is considerable evidence that a large part of the glucose catabolism of the lactating mammary gland of the rat occurs by way of the pentose phosphate pathway[1]. The effect of insulin on the relationship between glucose utilization and fatty acid synthesis has recently been investigated by Abraham *et al.*[2], who have shown that the addition of insulin to mammary gland slices from lactating rats caused an increased production of carbon dioxide labelled with carbon-14 from (1-^{14}C)glucose and an increased incorporation of glucose carbon into fatty acids.

There is also growing evidence that one of the factors controlling the activity of the pentose phosphate pathway in many tissues is the supply of

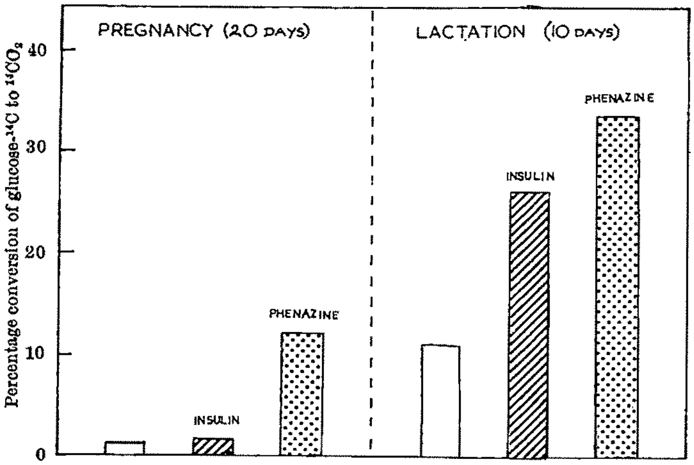

Fig. 1. Effect of insulin and phenazine methosulphate on the conversion of (1-^{14}C)glucose to labelled carbon dioxide by mammary gland slices from pregnant and lactating rats. 500 mgm. mammary gland slices incubated with 4·5 ml. Krebs–Ringer bicarbonate solution and 20 mgm. glucose containing 0·2 μc. (1-^{14}C)glucose. Gas phase oxygen + carbon dioxide (95 : 5). Incubation period 90 min. at 38° C. Additions to flasks: 1 I.U. insulin or phenazine methosulphate (final concentration 1×10^{-4} *M*)

oxidized triphosphopyridine nucleotide[3-5]. In the lactating mammary gland, as in most animal tissues, triphosphopyridine nucleotide is present almost exclusively in the reduced form[6]. It seemed possible that the stimulation of a reductive synthetic process utilizing reduced triphosphopyridine nucleotide, such as fatty acid synthesis, could lead to a parallel increase in the activity of the pentose phosphate pathway. One of the sites of action of insulin in the mammary gland might therefore be localized in the process of fatty-acid synthesis, the stimulation of which could produce a secondary effect on the activity of the pentose phosphate pathway. Evidence for this has been obtained from a study of the effect of insulin and phenazine methosulphate on the oxidation of either (1-^{14}C)glucose or (6-^{14}C)glucose by rat mammary gland slices at different functional stages. The results of some of these experiments are summarized in Fig. 1.

The marked difference in the effect of insulin on the oxidation of (1-^{14}C)glucose by tissue slices from pregnant and lactating rats can be seen in the histogram. Insulin has very little effect on the low rate of production of carbon dioxide labelled with carbon-14 by mammary tissue from pregnant rats, but causes a doubling of the rate of formation of labelled carbon dioxide by slices of lactating mammary gland. It seems probable that this difference between the glands from pregnant and lactating animals is related to their fat synthesizing capacity. Whereas the lactating gland has been shown to respond to treatment with insulin by an increase in the rate of formation of fatty acids[2,7], no such effect can be demonstrated in the mammary gland from pregnant rats.

The addition of phenazine methosulphate to slices of lactating mammary gland results in a stimulation of formation of labelled carbon dioxide from (1-^{14}C)-glucose as great as that found with insulin and, it should be noted, it produces an even more striking effect, a ten-fold increase, in slices of mammary tissue from pregnant animals. A series of other artificial electron acceptors produced similar effects.

The oxidation of carbon-6 of glucose is increased, but to a very much lesser extent, by the presence of phenazine methosulphate; insulin caused a pronounced decrease in the formation of labelled carbon dioxide from (6-^{14}C)glucose by mammary tissue from lactating rats. The increased production of labelled carbon dioxide from (1-^{14}C)glucose may thus be attributed mainly to an increased formation of labelled carbon dioxide by way of the first two, triphosphopyridine nucleotide-linked, steps of the pentose phosphate pathway.

It is suggested that the effect of phenazine methosulphate and of insulin in increasing the oxidation of glucose by way of the pentose phosphate pathway is mediated by increasing the rate of re-oxidation of reduced triphosphopyridine nucleotide; in the case of phenazine methosulphate by acting as an electron acceptor and of insulin by promoting the utilization of the hydrogens in the synthesis of long-chain fatty acids (see Hele, ref. 8).

This work will be reported in detail elsewhere.

The crystalline insulin, free from hyperglycæmic-glycogenolytic factor, used in these experiments was kindly given by Dr. Hallas-Møller, Novo Terapeutisk Laboratorium.

P. McLean

Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School,
London, W.1.
Nov. 25.

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Partition of Selenium-75 in the Intracellular Particulate Matter of Rat Liver

In the mammalian organism there is an apparent fixation of trace amounts of selenium in various tissue proteins. This has been demonstrated in studies of proteins from blood[1,2], liver[3,4] and leukocytes[5]. Hydrolysates of purified protein[4] of dog liver labelled with selenium-75 contain at least three different compounds with radioselenium. These compounds behaved like amino-acids in ion-exchange and precipitation studies and appeared on paper chromatograms in the (*a*) cystine and selenocystine, (*b*) methionine and selenomethionine, and (*c*) leucine areas. Neither the metabolic pathway or process by which inorganic selenium is converted to organo-selenium nor the biological function of selenium is known. Since time-distribution studies[6] have revealed that the highest average concentration of 19 per cent of the dose was found in the liver, and since the liver is generally considered the main site of protein synthesis, we have undertaken to study the distribution of selenium-75 in the intracellular particulate matter of rat liver.

Three adult male rats were injected subcutaneously with a single dose of selenious acid labelled with selenium-75 which contained approximately 0·225 mc.

Table 1. DISTRIBUTION OF SELENIUM-75 IN RAT LIVER CELLS (Values represent average of three experiments)

	Total selenium-75		Protein-bound selenium-75*	
	Percentage uptake	Activity per mgm. total nitrogen	Percentage uptake	Activity per mgm. total nitrogen
Homogenate	100·0†	1·00‡	80·3 ± 2·3	1·00‡
Nuclear fraction	2·7 ± 0·4	0·41 ± 0·04	87·4 ± 11·5	0·44 ± 0·03
Mitochondria	31·0 ± 1·6	0·66 ± 0·07	91·7 ± 2·2	0·76 ± 0·08
Microsomes	8·9 ± 1·7	1·26 ± 0·32	88·7 ± 5·1	1·39 ± 0·32
Soluble fraction	54·6 ± 1·1	1·47 ± 0·09	54·6 ± 3·7	1·00 ± 0·10

* Material insoluble in trichloracetic acid.

† 1 ml. homogenate = 23,673 c.p.m. (Exp. 1); 28,372 c.p.m. (Exp. 2); 28,842 c.p.m. (Exp. 3).

‡ Whole liver homogenate, 1·00.

of radioselenium and 0·03 mgm. of selenium per rat. The fasted animals were killed 24 hr. later, and the livers were removed, weighed and perfused with and homogenized in cold 0·44 *M* sucrose. Fractionation of the homogenate was performed essentially by the method of Dounce *et al.*[7]. Radioactivity was determined on aliquots of the homogenate and the nuclear, mitochondrial, microsomal and supernatant fractions. The nuclear and the mitochondrial fractions were washed three and two times respectively with 0·44 *M* sucrose. Total nitrogen was determined by the micro-Kjeldahl method of Clark[8]. Protein-bound selenium was determined by the standard tricholracetic method.

Results revealed that about one-half and one-third of the total selenium-75 activity, expressed as a percentage of the homogenate, were found in the soluble and mitochondrial fractions respectively, with smaller amounts in the remaining fractions. Total activity recovered was 97·2 ± 0·5 per cent, and total nitrogen recovery was 98·9 ± 4·2 per cent. The uptake of selenium-75 per mgm. of total nitrogen was found in decreasing amounts in the soluble, microsomal, mitochondrial and nuclear fractions respectively. The amount of selenium-75 precipitated with trichloracetic acid in all the fractions ranged from 70·1 to 96·2 per cent, except in the soluble fraction, where 48·5–57·9 per cent was found. Expressing the values on the protein-bound selenium basis, it was found that the microsomes had the highest values while the nuclear fraction had the lowest.

The preliminary studies on liver cell fractionation showed a wide but varied distribution of selenium-75 in the particulate matter. Expressed as protein-bound selenium-75 per mgm. nitrogen, the microsomes appeared to be the principal protein intracellular site of the uptake of radioselenium. However, the total amounts of selenium-75 activity in the soluble and mitochondrial fractions, which represent protein and non-protein radioselenium, respectively, were greater than those found in the microsomal and nuclear fractions.

Since fixation of selenium-75 in protein was found in all fractions studied, it appears that this phenomenon is not unique for any particular fraction. These findings are consistent with previous observations that trace amounts of selenium are fixed in a variety of proteins. On the other hand, the fact that all subcellular structures are able to fix selenium-75 in proteins may mean that all the particulate matter of liver cells plays a part in the fixation of selenium.

KENNETH P. MCCONNELL
DOROTHY M. ROTH
R. DUNCAN DALLAM

Radioisotope Service,
Veterans Administration Hospital,
and Biochemistry Department,
School of Medicine,
University of Louisville,
Louisville 2, Kentucky.

Oct. 29.

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Action of Nicotinamide on Acetoacetate Metabolism of Liver Homogenates of Normal and Alloxanized Rats

THE results of *in vivo* studies show that nicotinamide has a ketogenic effect on alloxanized rats[1,2]. On the other hand, Villa and Dioguardi[3] observed that nicotinamide considerably increases the oxygen consumption of liver homogenates of normal rats in a medium containing sodium acetoacetate, and they suggested that this effect is the result of stimulation of the keto-oxidative system. Recently, we observed[4] that the rate of oxygen uptake of liver homogenates of alloxanized rats rises after the addition of ethyl acetoacetate; but the oxygen consumption is not relatively higher after the addition of nicotinamide.

In the present study two series of tests were made in order to determine the effect of nicotinamide on oxygen and acetoacetate uptake of liver homogenates of alloxanized rats in media containing sodium acetoacetate in a Warburg respirometer at 30·4° C. We found: (1) The rate of oxygen uptake of the liver homogenate rises after the addition of sodium acetoacetate. Nicotinamide induces a further increase (Table 1). (2) Using liver homogenates from 25 rats under the same conditions, no significant difference in amount of acetoacetate (measured by two

Table 1

Homogenates	Media	Oxygen uptake mm.^{3}/hr. ± S.E.
Liver 100 mgm.	Buffer (phosphate *p*H 7·4)	23·46 ± 1·7
	Buffer + sodium acetoacetate (18 mgm. approximately)	36·25 ± 1·9
	Buffer + sodium acetoacetate + nicotinamide (2 mgm.)	52·14 ± 3·0

Table 2

Homogenates	Media	Amount of total acetone (in mgm.) after an incubation of 4 hr. ± S.E.
Liver 200 mgm.	Buffer + sodium acetoacetate (18 mgm. approximately)	7·54 ± 0·21
	Buffer + sodium acetoacetate + nicotinamide (2 mgm.)	7·48 ± 0·17

different methods) (ref. 5 and unpublished data of the authors, by a colorimetric method, based on Gerhart's ferric chloride reaction) was found after 4 hr. between experiments with and without added nicotinamide (Table 2).

We conclude that addition of nicotinamide to liver homogenates of alloxanized rats, containing sodium acetoacetate as substrate, increases the oxygen consumption in some conditions without any significant utilization of the acetoacetate.

S. Eser
S. Tekman
A. Araz

Institutes of Biochemistry and Physiopathology,
University of Istanbul,
Istanbul.

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Sparing Effect of Serum from Mice treated with Endotoxin upon Certain Murine Virus Diseases

Bacterial endotoxin has a complex pharmacological action upon animals ; this includes a febrile response beginning about 2 hr. after its intravenous or intraperitoneal inoculation. Blood serum from dogs[1] and rabbits[2] 2 hr. after the inoculation of endotoxin contains a pyrogen distinct from endotoxin[3,4]. It has been termed 'endogenous pyrogen' and is believed to be produced by damaged cells, notably leucocytes. Indeed, it has been suggested that cells damaged in ways other than by endotoxin produce endogenous pyrogen and that endogenous pyrogen may be the factor common to fevers of diverse etiology[4].

It has been shown that mice treated with endotoxin have increased susceptibility to the pathogenic action of ectromelia virus[5]. The facts mentioned above with regard to endogenous pyrogen suggested that the inoculation of serum of mice bled 2 hr. after injection with endotoxin might increase the susceptibility of mice to ectromelia virus in the same way as the inoculation of endotoxin. This possibility was tested as follows. Adult mice (strain *VS*) were bled 1$\frac{3}{4}$–2$\frac{1}{4}$ hr. after inoculation of endotoxin present in growth filtrates of *Salmonella typhimurium*[6]. Normal serum was prepared from comparable mice uninoculated with endotoxin. Each serum was inoculated intraperitoneally into 20 weanling mice (0·4 ml.), and 3 hr. afterwards both groups of mice, together with a group of 20 control mice, were inoculated intraperitoneally with 5 *LD*50 of ectromelia virus. A similar experiment in which the sera had been heated at 56° C. for $\frac{1}{2}$ hr. was also carried out.

Table 1

Source of serum	Unheated serum: Survival-rate 7 days after virus inoculation. Mice surviving/Mice in group	Unheated serum: Probability that difference is due to chance χ^2	P	Heated serum: Survival-rate 8 days after virus inoculation. Mice surviving/Mice in group	Heated serum: Probability that difference is due to chance χ^2	P
Endotoxin-treated mice	18/20	10·7	0·001	13/20	6·5	0·01
Normal mice	7/20			4/20		
Controls (no serum)	9/20			8/19		

The proportion of mice in each group which survived on the first day on which the mortality of the controls exceeded 50 per cent is shown in Table 1. It will be seen that significantly more of the mice survived which had received serum from endotoxin-treated mice, whether heated or unheated. The result was opposite to that expected, and suggested the presence in serum from mice treated with endotoxin of a substance which raises the resistance of mice to ectromelia virus. These experiments have been repeated with similar results.

Since the method of production of the protective serum has no obvious connexion with ectromelia, we considered that it might act in a similar way with other infections. We therefore studied its effect upon the mortality-rate which results from the dual infection of mice with *E. coccoides* and mouse hepatitis virus (*MHV* 1). It will be recalled that whereas *E. coccoides* is a harmless blood parasite of mice and mouse hepatitis virus causes a mild non-fatal hepatitis, infection of mice with *E. coccoides* followed by mouse hepatitis virus results in an acute hepatitis which is fatal in weanling mice[7,8].

Groups of 50 weanling mice were inoculated intraperitoneally with *E. coccoides* (0·2 ml. of blood containing the parasite diluted 10^{-6}) 24 hr. before the intraperitoneal inoculation of 10 *LD*50 of virus. Some groups were kept as controls, others were inoculated intraperitoneally with sera 3 hr. before the virus as in the previous experiments but the dose of serum was reduced to 0·2 ml. The results are shown in Table 2.

The proportion of survivors is higher in mice which received serum from mice reacting to endotoxin, whether fresh or heated, than in mice which received normal serum. The higher survival-rate in mice which received normal serum compared with that of the control mice which received no serum conformed to previous experience[9].

Preliminary experiments indicate that serum from rabbits reacting to endotoxin increases the resistance of mice to ectromelia ; rabbit serum has not yet been tested against *E. coccoides–MVH* 1 infection.

Table 2

Source of serum	Unheated serum: Survival-rate : Mice surviving / Mice in group	Unheated serum: Probability that difference is due to chance χ^2	P	Heated serum: Survival-rate : Mice surviving / Mice in group	Heated serum: Probability that difference is due to chance χ^2	P	Total: Survival-rate : Mice surviving / Mice in group	Total: Probability that difference is due to chance χ^2	P
Endotoxin-treated mice	36/49	5·2	$< 0·05$	35/49	3·5	$< 0·1$	71/98	9·5	$< 0·01$
Normal mice	24/49			25/49			49/98		
Controls (no serum)	16/48			13/49			29/97		

These results suggest the possibility that serum from animals reacting to endotoxin might show a similar protective effect against a wide variety of infections. We also consider that the protective substance may be present in the blood serum of animals reacting to toxic agents other than endotoxin, by analogy with the idea that endogenous pyrogen is produced by tissues damaged by diverse pyrogenic agents. These possibilities and the nature of the protective substance are being studied.

A. W. GLEDHILL

National Institute for Medical Research,
Mill Hill, London, N.W.7.
Nov. 12.

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Isolation of a Lipopolysaccharide from *Vibrio fetus*

Vibrio fetus infection is an important cause of infertility in cattle throughout the world. Little is known of the pathogenesis of this disease, partly because of the difficulty of obtaining massive growth of the vibrio *in vitro*. The recent development in this laboratory of a method of obtaining satisfactory yields of cells[1] has enabled fractionation studies on *Vibrio fetus* to be undertaken.

A toxic lipopolysaccharide has been isolated by the phenol extraction method of Westphal *et al.*[2]. Before extraction, flagella were detached by shaking the cells in sterile saline for 1 hr.[3], and surface antigens removed by treatment with 0·5 *M* potassium thiocyanate for 72 hr. at 37° C.[4]. The lipopolysaccharide was dialysed at 0° C. to remove all traces of phenol and gave a viscid, opalescent solution. An apparently identical lipopolysaccharide has been recovered from both smooth and rough forms of *Vibrio fetus*.

The substance conforms to the general characteristics of the lipopolysaccharides of Gram-negative bacteria in being toxic, pyrogenic and antigenic. Examination of a sample of the lipopolysaccharide by Dische's sulphuric acid – cysteine method[5] revealed the presence of an aldoheptose component. The absorption spectrum in a Hilger 'Uvispek' showed a curve suggestive of a lipopolysaccharide with a minimum contamination with nucleic acid. Hydrolysis with 1 per cent (v/v) acetic acid at 100° C. for 3 hr. yielded a small amount of a chloroform-soluble lipid.

The toxicity and pyrogenicity is greatly enhanced by heating the solution at 80° C. for 5 min. Rabbits are particularly susceptible, and deaths have occurred at the dose-level of 400 μgm./kgm. administered intravenously. The lethal dose is reduced to 40 μgm./kgm. rabbit by pre-heating. Nevertheless, rabbits withstand intramuscular injections of 10 mgm. of unheated lipopolysaccharide solution without apparent ill-effects. Mice are less susceptible, and the lethal dose is in the vicinity of 2 mgm. administered intravenously.

A febrile response in rabbits may be elicited with as little as 4 μgm./kgm., and the pyrogenic dose is reduced by heat treatment to as low as 0·005 μgm./kgm. Increases in temperature of 3–7·9° F. have been recorded. The temperature rises sharply within the first hour, reaches a peak in the majority of cases in 3 hr. and slowly falls to normal. The return to normal may take more than 24 hr.

Lipopolysaccharides, from both smooth and rough variants, are adsorbed on to human 'O' erythrocytes and give hæmagglutination when tested against homologous *Vibrio fetus* whole-cell rabbit antisera. The use of *Vibrio fetus* lipopolysaccharide in such a test may be of value in providing earlier and more accurate diagnosis of the disease in cattle. The lipopolysaccharide is a suitable antigen in the 50 per cent-hæmolysis-unit complement-fixation test using *Vibrio* antisera from rabbits. Further serological studies with this lipopolysaccharide are being undertaken.

I wish to thank Mr. R. V. S. Bain and Dr. K. Knox for their help and advice in these studies.

S. M. DENNIS

Department of Veterinary Pathology,
University of Sydney.
Nov. 11.

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Effect of Lytic Enzyme from *Bacillus circulans* and Chitinase from *Streptomyces* sp. on *Aspergillus oryzae*

THE enzyme contained in a culture fluid of *Bacillus circulans* has been shown to exert lytic activity towards *Aspergillus oryzae* and that a polymer of melibiose was liberated from the cell wall. However, the cell wall was not completely lysed by the enzyme owing to the large amount of chitin present. During the search for enzymes causing lysis of fungal cells, it was found that a mixed preparation of chitinase and lytic enzyme exerted strong lytic activity on the cell wall of *A. oryzae*.

In this communication some observations pertaining to the action of chitinase and lytic enzyme, and to the fine structure of the cell wall are given.

The cell wall and the lytic enzyme were prepared by methods previously described. The crude chitinase was used as a chitinase preparation[2]. The mycelia of *A. oryzae* which had been previously shaken in the peptone–starch medium for 12 hr. at 30° C. was used as intact cells. Washed living mycelia and the cell wall were suspended in the various enzyme solutions using *tris*-buffer *M*/50, *p*H 6·8 and were incubated at 37° C. Turbidity of the suspension was determined by the Itô Beckman type spectrophotometer at 10-min. intervals over a period of 1½ hr.

As shown in Fig. 1, the lysis progressed more rapidly when the lytic enzyme was added together with the chitinase than when added alone. Moreover, after 2 hr. had elapsed scarcely any cell wall and intact cells could be detected by either a phase-contrast microscope or an electron microscope.

40 mgm. of the cell wall were suspended in a solution consisting of 20 ml. of the lytic enzyme solution, 20 ml. of the chitinase solution or 20 ml. of the

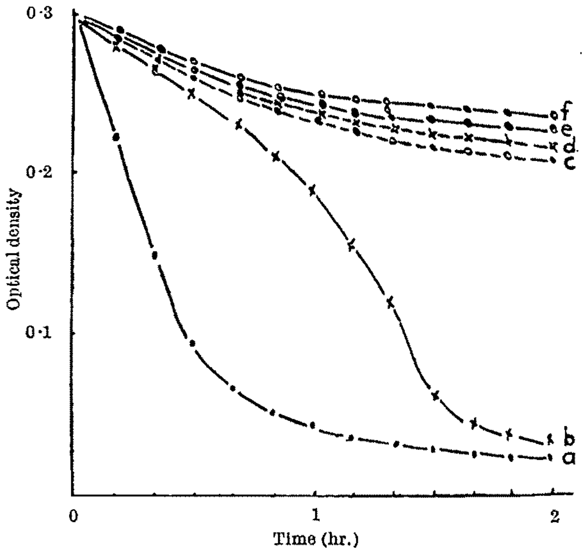

Fig. 1. Action of lytic enzyme and chitinase on the cell wall and on intact cells. Washed intact cells and cell wall were suspended in enzyme solutions (*tris*-buffer *M*/50, *p*H 6·8), and were incubated at 37° C. *a*, Cell wall (enzymes: lytic enzyme + chitinase); *b*, intact cells (enzymes: same as *a*); *c*, cell wall (enzyme: chitinase); *d*, cell wall (enzyme: lytic); *e*, intact cells (enzyme: lytic); *f*, intact cells (enzyme: chitinase)

chitinase and the lytic enzyme solution. About 5-ml. portions of this mixture were sampled at 30-min. intervals, and hexose and hexosamine liberated from the cell wall were determined by the anthron method[3] and by the modified method[4] of Elson and Morgan. Fig. 2 shows the experimental results.

From these results, it is concluded that the chitin-like fibre located on the cell wall is not chitin alone, but chitin coated by a melibiose polymer which could be lysed by the lytic enzyme from *Bacillus circulans*.

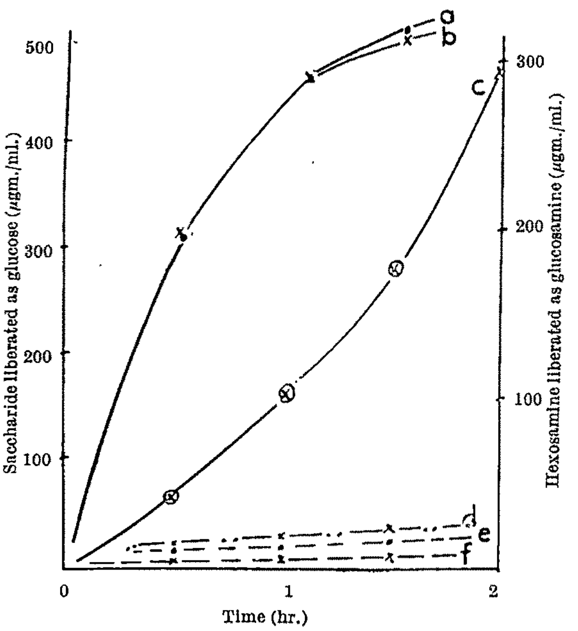

Fig. 2. Lytic action of lytic enzyme and chitinase on the cell wall. 40 mgm. of cell wall was suspended in 20 ml. of enzyme solution (*tris*-buffer *M*/50, *p*H 6·8), and these mixtures were incubated at 37° C. *a*, Saccharide (enzyme: lytic enzyme 24 μgm./ml. as N); *b*, saccharide (enzymes: lytic enzyme 24 μgm./ml. as N + chitinase 20 μgm./ml. as N); *c*, hexosamine (enzymes: same as *b*); *d*, hexosamine (enzyme: lytic enzyme 24 μgm./ml. as N); *e*, saccharide (enzyme: chitinase 20 μgm./ml. as N); *f*, hexosamine (enzyme: same as *e*)

We wish to express our appreciation to Drs. K. Sakaguchi and K. Arima for their valuable suggestions and to Drs. D. M. Reynolds and L. R. Berger who kindly sent us the chitinase.

KOKI HORIKOSHI*
Department of Agricultural Chemistry,
University of Tokyo,
Bunkyo-ku, Tokyo.

SHIGEJI IIDA
Scientific Research Institute, Ltd.,
Bunkyo-ku, Tokyo.

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* Present address: Division of Bacteriology, Department of Biological Sciences, Purdue University, Indiana.

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Factors inhibiting and stimulating Growth of *Mycobacteria* in the Blood and Serum of Non-immunized and Immunized Animals

RESISTANCE to infection with tuberculosis is determined by a number of factors, some of which restrict proliferation of the infective agent in the first stage of the infection. Various authors have demonstrated limitation of growth of the *Mycobacteria* not only in the cells of immunized animals but also in their tissue fluids[1-4].

In our experiments we first verified the results of Kotani *et al.*[5], obtained by culturing *Mycobacterium tuberculosis* (BCG) in drops of blood from healthy and infected rabbits. Like Kotani *et al.*, we found inhibition of growth of the *Mycobacteria* in the blood of the infected animals. On studying the relationship between the amount of inhibition of growth in the blood and serum of infected rabbits and the virulence of the strains or the amount of the infective dose, we found that small doses of a more virulent strain (total dose 0·1 mgm. and 0·4 mgm., intravenously) gave greater inhibition of growth.

We then studied the effect of different sera from normal and immunized rabbits on growth of BCG *Mycobacteria*. The method consisted in culturing BCG cells in a thin layer of 2 per cent glycerin agar on a slide in 2 ml. test serum. The agar was applied to the slide after mixing with a suspension of BCG *Mycobacteria* prepared by the method of Kotani *et al.*[5], in the ratio 10 : 1. After culturing for 48 hr. at 37° C., the slides were transferred to fresh serum and cultured for a further 48 hr. Growth of the *Mycobacteria* was then evaluated by counting the number of cells in each microcolony, as in the experiments of Kotani *et al.*

When BCG *Mycobacteria* were cultivated in the serum of normal rabbits, great differences in their growth activity were observed. In the sera of 24 rabbits examined in the course of one year, the average growth of *Mycobacteria* varied from 2·0 up to 7·5 rods per microcolony in different animals. This decrease of growth in individual sera may be due to a naturally occurring antimicrobial substance[6].

A further increase in the inhibitory action of rabbit sera was observed after immunization of these animals with killed vaccine of *M. tuberculosis* var. *bovis* (Duprey) (Table 1, Fig. 1, *a*, *c*). Heating the sera of non-immunized and immunized rabbits at 56° C. for 30 min. did not affect growth of the BCG cells;

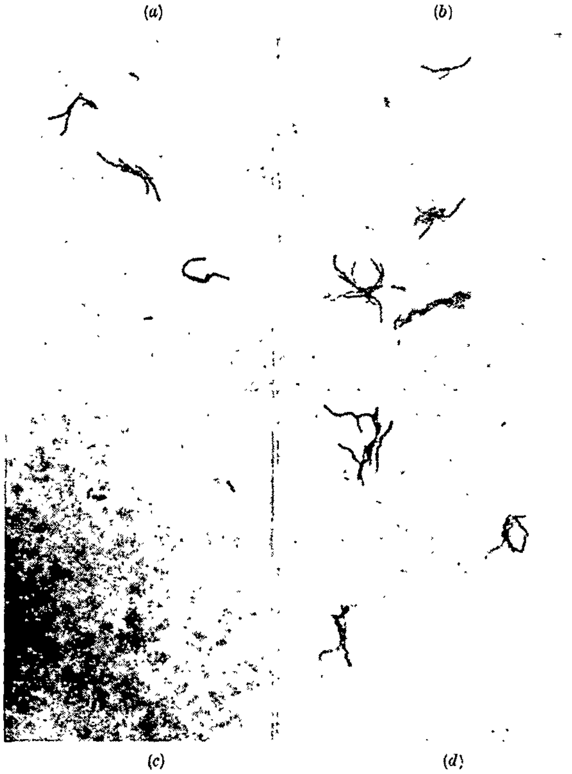

Fig. 1. Growth of cells of *Mycobacterium tuberculosis* var. *bovis* (BCG). (a) In serum of normal, non-immunized rabbits; (b) in the same sera heated to 70° C. for 30 min.; (c) in serum of immunized rabbits; (d) the same serum heated to 70° C. for 30 min. The rabbits were immunized intravenously with 4 mgm. inactivated vaccine (*M. tuberculosis* var. *bovis* (Duprey))

growth increased only when the sera were heated at 70° C. for 30 min. (Table 1, Fig. 1 *b*, *d*). In both groups of animals, growth of the *Mycobacteria* was then the same. It was further found that growth of BCG *Mycobacteria* was completely inhibited by adsorption of the sera of control animals by a concentrated suspension of living or killed cells of these *Mycobacteria*, and that it was not renewed even when the sera were heated at 70° C. This is the basic difference as compared with the serum of immunized rabbits, in which growth of BCG *Mycobacteria* was completely inhibited, but in which, on heating at 70° C., growth of BCG cells reached the same values as in the controls.

Table 1. Growth of Cells of *Mycobacterium tuberculosis* var. *bovis* (BCG) in Serum of Non-immunized and Immunized Rabbits. The Figures refer to the Average Number of Cells in the Microcolony

Rabbit No.	Immunization (mgm.)	Growth of BCG cells in serum			
		Control	Heated at 56° C.	Heated at 70° C.	Adsorbed by BCG
718	—	2·6	2·7	3·8	1·0
721	—	4·4	3·8	6·9	1·0
723	—	4·6	4·2	6·3	1·0
724	—	3·5	3·0	6·5	1·0
725	—	3·0	3·7	8·3	1·0
726	—	3·2	2·9	7·2	1·0
Average		3·5	3·4	6·5	1·0
22	4	1·0	1·0	5·4	1·0
168	4	1·0	1·0	7·2	1·0
170	4	1·0	1·1	3·1	1·0
171	4	1·2	1·1	9·6	1·0
174	4	1·1	1·0	8·7	1·0
Average		1·0	1·0	6·8	1·0

Complete inhibition of growth of *Mycobacteria* was also observed in adsorption of sera by *M. tuberculosis* (Duprey). This did not occur, however, in adsorption of the sera by other groups of micro-organisms (*Saccharomyces cerevisiae, Diplococcus pneumoniae*). We believe the complete inhibition of growth of BCG *Mycobacteria* is due to the disappearance of some growth factor. Indeed, electrophoresis of the sera showed that the alpha-globulin fraction disappeared in serum adsorbed in this way.

These results show that after immunization of rabbits, the level of lysozyme may rise and antibodies may be formed which indirectly affect the inhibitory action of the naturally occurring thermostable antimicrobial substance. The important role of antipolysaccharide antibodies in tuberculosis immunity was described by Seibert[7]. These antibodies combine with the freely circulating tuberculopolysaccharide and thus prevent binding with the effective groups of the natural antimicrobial factor. This factor can then influence the growth of the *Mycobacteria* more effectively. Our results of the study of the relationship between inhibition of growth in rabbit serum and the size of the infection dose showed that the administration of large doses completely suppresses the inhibitory effect of the sera on growth of the *Mycobacteria*. This immunological paralysis is evidence that the inhibitory factor in the serum of immunized animals is of an antibody character.

It was also found that rabbit serum contains a substance promoting growth of *Mycobacteria* which can be removed by its adsorption by *Mycobacteria* suspensions and is to be found in the alpha-globulin fraction of serum. The activating effect of serum albumin[7] may be due to alpha-globulin which is carried over into the albumin in the commonly used fractionation procedures.

J. Hubáček
I. Málek

Institute of Biology,
Czechoslovak Academy of Sciences,
Prague.

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Effects of Starvation and Diphenylamine on Carotenoids in *Phycomyces*

In cultures of *Phycomyces blakesleeanus* treated with diphenylamine and methylheptenone, the synthesis of the more saturated polyenes is enhanced at the expense of β-carotene[1,2]. Diphenylamine has a similar effect on cultures of *Rhodospirillum rubrum* at the expense of spirilloxanthin[3]. This effect of diphenylamine has been interpreted as blocking a series of dehydrogenation steps in the transformation of the more saturated to the less saturated carotenoids. Leucine, on the other hand, which stimulates production of β-carotene, contributes to intermediates in carotenoid synthesis.

Two effects are reported in this communication: (1) that of starvation of fully grown mycelial mats of

P. blakesleeanus on the carotenoid content; (2) those of β-ionone, diphenylamine, methylheptenone and leucine on the content and changes in composition when the starved mats are afterwards transferred to an energy-rich medium.

Cultures of *P. blakesleeanus* were grown in 250 ml. Erlenmeyer flasks containing a shallow layer (20 ml.) of medium consisting of 2·5 per cent glucose and 0·3 per cent Difco yeast extract. After 5 days, the medium was decanted off, the mycelium washed three times with sterile water, suspended in sterile water and kept for 24 hr. in the dark. The mycelium was then transferred to 1 per cent Wickerham carbon base medium together with the compound the effect of which was to be tested. The mats were harvested at definite time-intervals and examined for the carotenoids as described earlier[2]. Results are shown in Table 1 for β-carotene and in Table 2 for other components.

Table 1. EFFECT OF STARVATION AND TRANSFER ON β-CAROTENE CONTENT

Treatment	β-Carotene (μgm.)				
	Experiment No. 1	2	3	4	5
Control (5 days growth)	30	33	31·6	32	—
Control (24 hr. starvation)	8·1	10·7	11·0	7	15·7
Control (24 hr. after transfer)	18·6	—	12·0	12	19
β-Ionone (24 hr. after transfer)	156·8	—	—	92	50
Diphenylamine (24 hr. after transfer)	—	—	31·0	—	45
Methylheptenone (24 hr. after transfer)	—	—	9·7	—	—
Leucine (24 hr. after transfer)	—	—	10·7	17	—
Control (no starvation; no transfer; that is, 6 days growth)	43·2	—	—	—	—

Table 2. EFFECT OF STARVATION AND DIPHENYLAMINE ON POLYENE CONTENT

Treatment	Phytoene (μgm.)	Phytofluene (μgm.)	β-Carotene (μgm.)	ζ-Carotene (μgm.)
Control (5 days growth)	33·6	12·3	29·1	3·4
Control (starved 24 hr.)	25·3	3·7	14·1	2·6
Control (1 hr. after transfer)	30·6	5·1	6·2	5·2
Control (4 hr. after transfer)	21·5	5·1	8·5	3·5
Control (12 hr. after transfer)	23·2	5·9	10·9	3·4
Diphenylamine (1 hr. after transfer)	74·0	10·0	24·4	4·3
Diphenylamine (4 hr. after transfer)	48·8	8·1	26·0	5·1
Diphenylamine (12 hr. after transfer)	53·3	7·8	24·3	4·7

It is seen from Tables 1 and 2 that between 50 and 75 per cent of the β-carotene is lost by starvation, and there is limited recovery as a result of transferring the control to the energy-rich medium without further treatment. Furthermore, treatment with methylheptenone, and more surprisingly with leucine, has no effect on β-carotene synthesis. With diphenylamine, however, the β-carotene-level of the pre-starved mat is rapidly restored.

Loss in β-carotene by starvation is not counterbalanced by gains in phytoene, phytofluene or ζ-carotene. (The neurosporene and lycopene contents are too small to be a factor.)

In the presence of diphenylamine the phytoene rises to a higher level than that in the pre-starved control. A net synthesis of phytoene has therefore occurred. This is not true of phytofluene, which although significantly higher than the starved and transferred control is still below the initial pre-starved level.

The effects of starvation and subsequent transfer on carotenoid-levels compared with those of the pre-starved may be summarized as follows:

Control, transferred: net losses in phytoene, phytofluene and β-carotene.

Treated with diphenylamine, transferred: net gain in phytoene, net loss in phytofluene, no change in ζ-carotene.

The restoration of β-carotene to virtually the pre-starvation-level as a result of treatment with diphenylamine requires explanation. Starvation causes no increase in other carotenoids at the expense of β-carotene. If, therefore, diphenylamine is to play its traditional part of anti-oxidant, it must be in preventing further breakdown of polyene precursors. Thus, 1 hr. after transfer, the β-carotene concentration is still decreasing in the control, whereas the trend is completely reversed in the cultures treated with diphenylamine.

Grants from the National Institutes of Health and from the National Science Foundation in support of this work are gratefully acknowledged.

T. N. R. VARMA
C. O. CHICHESTER
G. MACKINNEY

Department of Food Technology,
University of California,
Berkeley-Davis, California.
Nov. 18.

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Changes in Œstrogen Titre in Stored Urine

NUMEROUS examples of microbiological reactions on steroids have been reported, and it has been suggested that the presence of bacterial enzymes in urine may cause steroid transformations[1].

In preliminary experiments designed to exaggerate any changes which might occur in the œstrone, œstradiol-17β and œstriol values, urine was kept for several weeks, both at room temperature and at 4° C. Significant increases were found to occur in the œstrone and œstradiol-17β fractions of normal male urine but not in the œstriol fraction. Even more striking changes occurred in stored urine from an oophorectomized woman with carcinoma of the breast, collected after the injection of 2·5 mgm. of œstradiol-17β (Table 1).

The results of the chemical determination[2] were confirmed by biological assay (kindly carried out by Mr. P. C. Williams).

Accompanying changes in titre, considerable hydrolysis of the conjugated œstrogens occurs at room temperature. Four urines were analysed for

Table 1. CHANGES IN ŒSTROGEN TITRE IN URINE STORED FOR A LONG PERIOD

Results of duplicate estimations expressed as μgm./24 hr. For calculations of *P*, see Brown, Bulbrook and Greenwood (ref. 3)

	Initial	9 weeks at room temperature	*P*	10 weeks at 4° C.	*P*
Œstrone	3·3	17·7	$< 0·001$	64·3	$< 0·001$
Œstradiol-17β	3·2	7·1	$< 0·001$	0	$< 0·001$
Œstriol	3·1	3·2	—	0	$< 0·001$

Table 2. URINARY ŒSTROGEN TITRE UNDER NORMAL STORAGE CONDITIONS

	Initial	2 days at room temperature	6 days at 4° C.
Total œstrogen			
Mean	14·0	15·1	14·2
	(6)	(6)	(6)
S.D.	± 16·0	± 16·5	± 16·7

No. of duplicate estimations in parentheses. Results calculated as µgm./24 hr.

free œstrogens after ten weeks at room temperature; and from 62 to 74 per cent of the œstrone fraction, 0–45 per cent of the œstradiol-17β fraction, and 62–100 per cent of the œstriol fraction were found to be in the free form.

The increase in the œstrogen content of stored urine could possibly be accounted for by the transformation of one or more of the œstrogen metabolites known to be present in human urine but not measured by Brown's method. After four weeks on the bench or at 4° C. an increase from zero to 12 µgm. of œstriol was found in a specimen to which 16α-hydroxyœstrone had been added, compared with no change in a control urine. Micrococci and diphtheroids were shown to be present in the urine but no attempt was made to determine whether the steroid transformation was due to the presence of these micro-organisms or to the increase in the alkalinity of the urine.

In normal circumstances changes have not been found to occur providing the urine is not kept for more than two days at room temperature or for more than a week at 4° C. (Table 2).

Although there were slight individual variations there is no significant difference between the three sets of results.

If urine is stored for any length of time, hydrolysis of the conjugates and destruction or transformation of the œstrogens may occur. The changes are not predictable or constant and unless analyses are carried out within two days at room temperature, or within one week at 4° C., the results may have little reference to the original titre of œstrone, œstradiol-17β and œstriol. However, it has been shown[3] that no loss of œstrogen occurred in a single specimen of urine stored at −10° C. for two months.

Y. A. LEON
R. D. BULBROOK
F. C. GREENWOOD

Clinico-Pathological Laboratories,
Imperial Cancer Research Fund,
Royal College of Surgeons,
London, W.C.2.
Nov. 25.

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Method for testing the Influence of Drugs and Physical Agents upon Mitosis

JOLLY[1] described how to obtain a convenient number of erythroblastic mitoses in the circulating blood of various species of *Triturus*. The new techniques now made available by phase-contrast microscopy induced us to study these cells with time-lapse photography and micro-cinematography in order to obtain direct evidence of the mechanism of normal and artificially influenced mitosis.

The method can be summarized as follows. According to Jolly the newts are left absolutely without food for 2–6 months; after this period the animals are put in a thermostatic enclosure at 26° C. and fed for some days with earthworms. Generally, between the second and fourth day of feeding a good number of erythroblastic mitoses appear in the circulating blood of the newts. At this moment a blood smear is taken from the tail of the animals and stained as a control. Afterwards the newts are treated according to the aims of each particular experiment (intraperitoneal injections, exposure to radiations or gases, etc.); at various intervals small drops of blood are then taken from the tail of the animals, put on a slide, covered gently with a cover slide and sealed with paraffin.

The preparations are put under the phase-contrast microscope for time-lapse photography or cinematography; in order to keep the temperature constant during observation, the microscope is put in a special thermostatic enclosure. At the same time blood smears are prepared and stained. In certain cases it may be also advisable to act directly on the surviving erythroblasts of an untreated newt, adding the substance to the blood drop or exposing it to radiations, gases, etc.

Thus it is possible to follow and to document with films or photographs the course of mitosis and the various alterations eventually induced. Additional results are obtained from the stained smears.

Obviously, a great number of modifications to the method we have outlined may be necessary. In fact, our test is adaptable to many different experimental conditions, but is particularly suited when clear morphological evidence is needed. A series of detailed papers is in preparation, dealing with normal mitosis and the influence of various substances and physical agents upon it.

ELIO GUIDO RONDANELLI
PASQUALE GORINI
DOMENICO PECORARI

Clinica Medica Universitaria,
Pavia.
Nov. 10.

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Splitting of the Electrophoretic Pattern of Serum Albumin during Short-term Action of Pepsin at Room Temperature

THE heterogeneity of serum albumins consisting of several molecular sub-units has been established by chemical as well as by electrophoretic assays. However, while chemical fractionation of serum albumins led to well-identified products, electrophoretic procedures did not show equally consistent results. In this latter case, the separation of the sub-units was found to vary with *p*H, ionic strength, length of run, and other factors not well understood[1]. It could be shown, moreover, that the splitting of albumin into a number of boundaries is a reversible process and does not represent denaturation on artefacts.

A similar but apparently irreversible splitting of serum albumin into molecular sub-units, by the short-term action of pepsin, is demonstrated in the present electrophoretic studies carried out by Tiselius's moving boundary method.

The analyses were initiated with crystalline bovine serum albumin (Armour). 100 mgm. albumin was dissolved in approximately 10 ml. distilled water

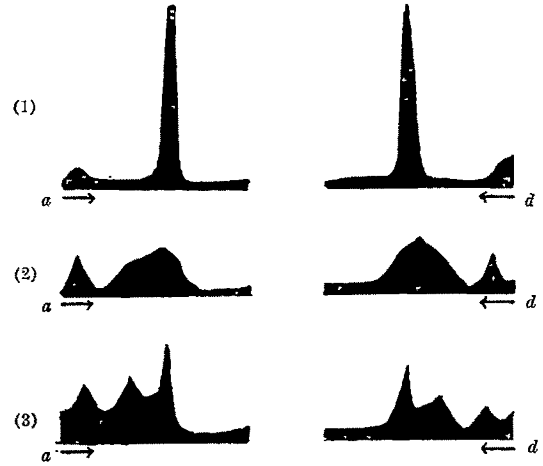

Fig. 1. Electrophoretic pattern of 1 per cent crystalline bovine serum albumin incubated with pepsin in a ratio 1 : 100 at room temperature: (1) at *p*H 7·0 for a 6-min. period; (2) and (3) at *p*H 3·0 for a 2- and 6-min. period respectively at room temperature

and the *p*H adjusted to 3·0. The solution was then incubated with 1 mgm. crystalline pepsin (Nutritional Biochemicals Corp.) at room temperature for 1–6 min., after which a proportional mixture of crystalline veronal and sodium veronal was dissolved in the sample in order to inactivate the ferment and to make its barbiturate – barbituric acid concentration equal to that of the buffer solution used in the electrophoretic experiment.

For the preparation of albumin from fresh cow, horse, rabbit and cock serum, a simple and relatively quick method had to be utilized that would be applicable to small amounts of blood, and which would provide an electrophoretically homogeneous product. The trichloracetic acid–acetone extraction procedure of Kallee and associates[2], modified slightly, gave satisfactory preparations. In most cases 3 ml. of the respective serum sample was used for the extraction. The acetone of the extract was removed by vacuum distillation at room temperature and the remaining aqueous suspension of albumin redissolved at *p*H 6·5 by addition of sodium hydroxide. The solution was clarified by high-speed centrifugation, dialysed against 4 l. of distilled water in the cold for 24 hr., after which the *p*H was brought to 3·0 and incubated with pepsin in a 1 : 100 ratio as described above. The protein content of the samples was determined according to the method of Gornall *et al.*[3]. The readily reproducible electrophoretic assays were made in 2 ml. cells by means of a Perkin–Elmer electrophoretic apparatus, model 38, using veronal buffer of *p*H 8·6, ionic strength 0·1, and a potential gradient of 7·10 to 7·30 V./cm.

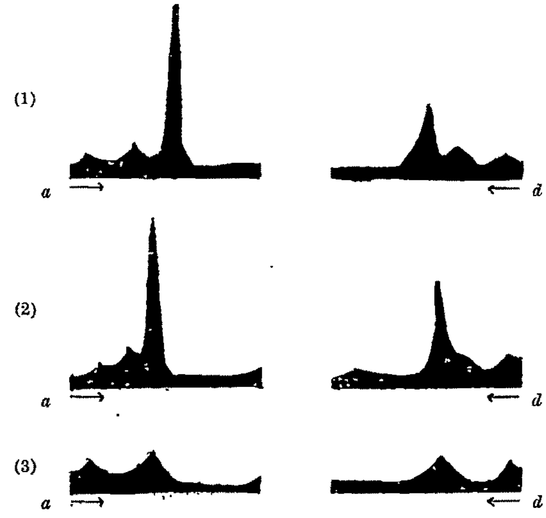

Fig. 2. Electrophoretic patterns of solution of (1) 0·87 per cent rabbit serum albumin, (2) 0·91 per cent cock serum albumin, and (3) 0·64 per cent horse serum albumin incubated with pepsin in a ratio 1 : 100 for a 6-min. period at room temperature

Fig. 1 shows the elctrophoretic pattern of 1 per cent crystalline bovine serum albumin after incubation with pepsin for 2 and 4 min., respectively. The two patterns differ primarily in the number and shape of their boundaries, which would indicate that the separation of the boundaries into two or three peaks depends upon the time-period allotted to the pepsin albumin constituents to react with each other.

Fig. 2 shows the electrophoretic pattern of rabbit, cock and horse serum albumin as influenced by the action of pepsin. On comparing the patterns of Figs. 1 and 2 the differences between the species different albumin samples are easily recognizable.

Thanks are due to Mr. J. A. G. Larose for valuable technical assistance.

E. Annau

Animal Diseases Research Institute,
Department of Agriculture,
Hull, Quebec. Oct. 6.

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Has Water a Specific Taste?

In 1949 it was found that water applied to the tongue of the frog elicited an electrical response from the glossopharyngeal nerve[1]. This response was produced by specific fibres[2]. It was first thought that these 'water' fibres might serve a particular purpose in water regulation in amphibians living in fresh water. These findings also revived the old problem of whether warm-blooded animals and man possess similar specific taste fibres mediating what we might call a water taste. The late Prof. David Katz of Stockholm, who believed this to be the case, often asked in his examinations: What is the taste of water? The correct answer was 'wet'.

Such a belief was strengthened by the fact that Liljestrand[3] demonstrated that as weak a salt solution as 0·009 *M* sodium chloride which does not taste salty could be distinguished from distilled water with 100 per cent certainty if the solutions had been boiled and cooled down again to the same temperature.

Experiments on cats, dogs, pigs[3,4] and recently even monkeys have shown that these animals possess specific nerve fibres in their chorda tympani which respond to the application of water to the tongue. In the rat, on the other hand, an application of water to the tongue does not produce any positive response as it does in the cat; but a negative response is obtained which is due to an abolition of the rather high spontaneous activity of the salt fibres[5].

In the animals which possess specific water fibres as well as salt fibres, the discrimination of weak salt solutions from pure water could thus be elaborated by a dual system of salt and water fibres, the activities

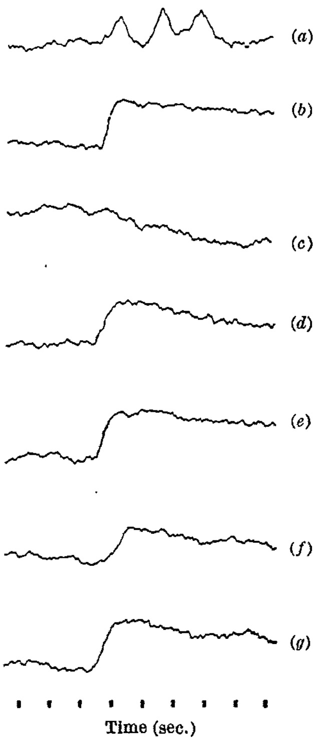

Fig. 1. Integrated responses of the whole chorda tympani nerve of man to touch and to various solutions flowing over the tongue: (a) touch, (b) 0·5 *M* sodium chloride, (c) distilled water, (d) 15 per cent sucrose, (e) 0·04 per cent saccharine, (f) 0·02 *M* quinine, (g) 0·2 *M* acetic acid

of which contrast with each other because of their reciprocal mode of stimulation, in the same way as do the cold and warm fibres in our thermal discrimination. A few years ago preliminary experiments on man were performed by Dr. C. Åhlander and one of us (Y. Z.) on man during operations on the middle-ear[6]. Out of ten trials very weak responses were obtained in two cases to touch, cold and gustatory stimulation of the tongue. The responses were, however, only very faintly audible in the loud-speaker and could not be recorded.

In recent attempts, made in the otological clinic of Karolinska Sjukhuset, we have been able to record the electrical response from the chorda tympani during operations carried out to mobilize the stapes in the middle-ear. In two out of six cases we have been able to record the integrated electrical response of the nerve when the tongue was stimulated by touch and various solutions. As will be seen in Fig. 1 there is a good response to 0·5 *M* sodium chloride solution as well as to 15 per cent sucrose, 0·04 per cent saccharine, 0·02 *M* quinine hydrochloride and 0·2 *M* acetic acid.

The application of water to the tongue, however, is followed by a negative response, in that water abolishes the spontaneous activity of the taste fibres just as has been described in the rat. As our evidence, however, is based upon successful experiments in only two humans, we have to collect more evidence before being able to say definitely that man lacks a specific water taste. Introspectively, however, it seems to us most likely that water does not elicit any positive taste sensation. The action must be of negative character in that water abolishes or decreases the resting activity of taste fibres, particularly that of salt fibres. The specific effect of water on taste in man can thus be looked upon as being of the same nature as that of blackness upon vision. This is in interesting contrast to the monkey, in which we have recently found a comparatively strong positive response to water.

Yngve Zotterman
Department of Physiology,
Veterinärhögskolan,
Stockholm 51.

Herman Diamant
Otolaryngological Department,
Karolinska Sjukhuset,
Stockholm 60. Nov. 6.

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Haptoglobin Types in American Negroes

Since the discovery by Smithies[1] that there are genetically controlled serum haptoglobin types, two reports on the distribution of these types among African Negroes have been published. Sutton *et al.*[2] noted a 49 per cent incidence of haptoglobin type 1-1 among Liberian and Ivory Coast natives. A similar percentage (54 per cent) was found by Allison *et al.*[3] in Nigerians. However, a great discrepancy between the two studies was described by Allison, who found that 32 per cent of the Nigerian sera did not contain demonstrable haptoglobins—a condition not reported by Sutton. Allison pointed out that since the Michigan investigators did not add hæmoglobin to the sera prior to electrophoresis, and the starch gel was not stained with benzidine, sera devoid of haptoglobins could be readily confused with those of type 1-1.

Nosslin and Nyman[4] have shown that, in the presence of hæmolytic anæmia, the amount of serum haptoglobin may be greatly decreased or absent. That the high incidence of malaria and hæmoglobinopathies associated with red cell destruction in African Negroes might obscure the true incidence of their haptoglobins was implied by Allison. Nevertheless, he felt that the phenomenon of 'ahaptoglobinæmia' should be ascribed to a genetic mechanism.

Since malaria is extremely rare in the north-western part of the United States, the Seattle area seemed especially suitable for testing the serum of American Negroes for their haptoglobin types. Employing Smithies's method[5], starch gel electrophoresis was performed on the serum of 406 random Negro donors at the King County Central Blood Bank. Oxyhæmoglobin was added to a concentration of about 300 mgm. per cent prior to electrophoresis. The resultant starch strips were treated with benzidine and the haptoglobin type read immediately. Amido black *B*-10 staining was then carried out. With this method, the benzidine-stained bands were characterized by a permanent black colour distinct from the blue non-hæmoglobin protein.

A control group of 100 sera from white donors showed a distribution of haptoglobin types very similar to that reported by other authors[2,3,6]. However, the Negro sera, as indicated in Table 1, were different in several respects from those described in Africans.

Complete absence of haptoglobin was observed in a much smaller percentage of subjects than reported

Table 1. HAPTOGLOBIN TYPES IN NEGROES

Locale	Number tested	Haptoglobin types (per cent)				
		1-1	2-2	2-1	2-1 (mod.)	Absent
Nigeria (ref. 3)	99	53·5	3·0	11·1	—	32·3
Liberia and Ivory Coast (ref. 2)	142	48·7	9·1	42·3	—	—
Seattle	406	26·4	21·4	38·2	9·8	4·2

in Nigerians. Recognition of such individuals was difficult because of the necessity to distinguish their sera from that containing very small amounts of hæmoglobin-binding protein. In about 5 per cent of cases, the area stained with benzidine was so faint that it was necessary to repeat the electrophoresis to confirm the presence of haptoglobin. In several instances, new samples were obtained; but the same phenomenon was observed.

Seventeen, or 4·2 per cent of all sera tested, appeared to be completely devoid of haptoglobin. The donors of these samples were not anæmic and none had a history of malaria. Of six red cell specimens from 'ahaptoglobinæmic' Negroes neither unusual hæmoglobins nor a deficiency in glucose-6-phosphate dehydrogenase, which is associated with hæmolysis due to a variety of agents[7], could be demonstrated (hæmolysis performed by Dr. A. G. Motulsky, University of Washington School of Medicine). Inheritance studies of 'ahaptoglobinæmia' have so far been inconclusive. However, in some families, both parents of a subject with 'ahaptoglobinæmia' appear to carry a pair of normal haptoglobin genes. Thus, it is clear that if a genetic mechanism is involved, the responsible gene cannot be an allele at the *Hp* locus, nor can it be a Mendelian dominant.

Forty of the sera (9·8 per cent) showed a pattern similar to that of type 2-1, but distinctly different in having a much heavier concentration of haptohæmoglobin in the region just behind the beta-globulin (as seen in type 1-1) as well as the fastest of the zones in the 'alpha-beta' region. The other bands characteristic of type 2-1 were either entirely absent or scarcely discernible. In a recent paper, Connell and Smithies[8] describe the same unusual type, and illustrate the starch gel patterns of purified haptoglobins of this and the three common types. They suggest the tentative name '*Hp* 2-1 (mod.)' for this modified type. It is not yet known whether the pattern is due to a third allele at the *Hp* locus or to the effect of a modifying gene. Studies of its inheritance are in progress.

The lower incidence of 'ahaptoglobinæmia' and higher incidence of the Hp^2 gene in Seattle Negroes as compared with African natives may be explained by the following factors: (1) The present study was performed on the serum of healthy blood donors from an area essentially free of malaria. (2) Seattle Negroes represent several sections of Africa, where haptoglobin type distribution is probably variable. (3) Racial intermarriage in America, known to have produced an admixture of 30 per cent of European blood group genes in Negroes[9], undoubtedly has a similar influence on haptoglobin gene frequencies.

ELOISE R GIBLETT

King County Central Blood Bank,
Seattle, Washington. Nov. 18.

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Hæmoglobin *N* in Portuguese Guinea

IN 1956 a survey of hæmoglobin types in Liberians by Robinson, Zuelzer, Neel, Livingstone and Miller led to the discovery of two 'fast-moving' hæmoglobins which were provisionally designated Liberian I and II, the first abnormal complement moving on electrophoresis at *p*H 8·6 faster than the second and both moving faster than normal adult hæmoglobin *A*. Liberian I was at first supposed to be identical with hæmoglobin *J* discovered by Thorup, Itano, Wheby and Leavell[1]; but further study by Ager and Lehmann[2] demonstrated a difference in the behaviour of these hæmoglobins, Liberian I migrating faster than *J* at alkaline *p*H, though slower than *H* or *I*. At acid *p*H Liberian I separates from *A* towards the anode while *J* does not. Liberian I, thus being a new hæmoglobin, was called hæmoglobin *N*.

Hæmoglobin *N* is a rare type, having been found only eight times in the survey by Robinson *et al.*[3] among the Mande tribe in Central Liberia. During a survey of abnormal hæmoglobins in Portuguese Guinea we have found fourteen Africans with this rare variant. We are indebted to Dr. H. Lehmann, of the Department of Pathology, St. Bartholomew's Hospital, London, for having classified the abnormal hæmoglobin in the first instance when it was found. Fig. 1 shows its mobility on paper electrophoresis at *p*H 8·6 in the hands of this investigator. Subsequent hæmoglobins have been classified by ourselves in comparison with samples of hæmoglobins *J* and *H* very kindly supplied by Dr. Lehmann, the original hæmoglobin *N* found by us, and a sample of hæmoglobin *K* obtained at a previous survey in the St. Thomas and Prince Islands[4].

Hæmoglobin *N* was found in Portuguese Guinea in the following tribes in random samples of blood

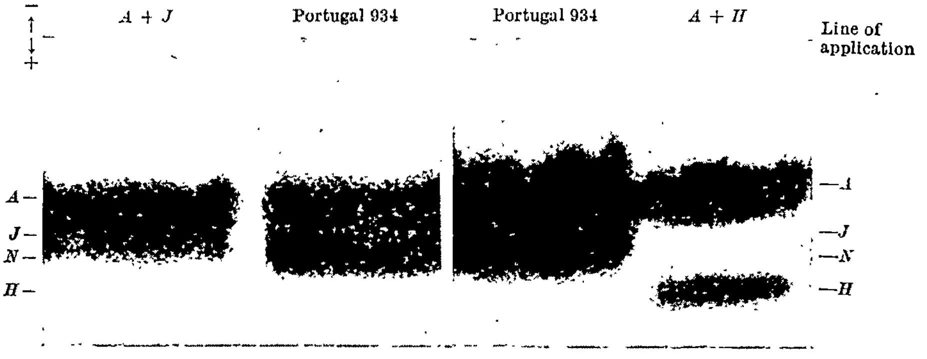

Fig. 1. Comparison of Portugal 934 with hæmoglobins $A+H$ and $A+J$. It will be seen that at paper electrophoresis *p*H 8·6 the 'fast-moving' component of Portugal 934 is slower than *H* and faster than *J*

(number of samples given in parenthesis): Fula, 4 cases (1,553); Beafada, 1 (797); Pajadinca, 2 (300); Sôsso, 2 (94); Balanta, 1 (776); Mancanha, 1 (534); Manjaco, 3 (758).

The first four tribes are Moslems, the latter Fetichists. The general search allowed the examination of 9,224 samples of blood gathered throughout the Province.

CARLOS TRINCÃO
L. T. DE ALMEIDA FRANCO
A. R. NOGUEIRA

Instituto do Medicina Tropical,
Lisbon.

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Oxygen Consumption of Different Forms of Stable L *Proteus* P 18 growing in Hypertonic Liquid Medium

IN previous work we have studied the oxygen and glucose consumption as well as the lactic acid production of the *Proteus* Ahmed bacillus and of a stable L form which is derived from it[1].

We then noticed that the oxygen and glucose consumption of the bacillus were respectively 4·0 and 5·1 times higher than that of the L form, whereas the lactic acid production was only 2·4 times greater. The share of anaerobic glycolysis in the glucose degradation was more considerable with the L forms than in the rod forms.

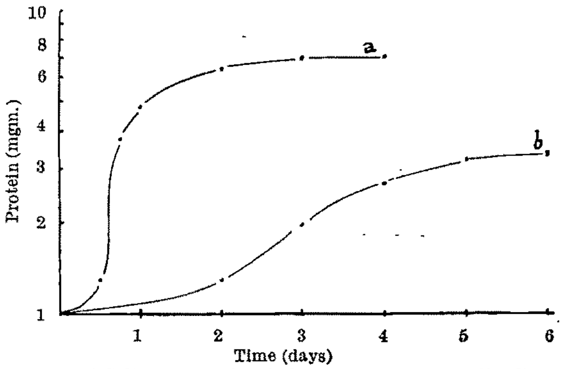

Fig. 1. (*a*) Culture suspensions in hypertonic medium; (*b*) culture films (*voiles*) according to Tulasne (ref. 2)

Owing to the heterogeneity of the L form cultures, it was interesting to investigate the metabolic characteristics of several morphological forms: large, small and elementary filterable bodies. First, a technique for obtaining readily large quantities of L forms was devised, because the usual methods[2,3] were found to be laborious and difficult. We have used films (*voiles*[2]) of L forms of *Proteus* P 18 to produce culture-suspensions in hypertonic medium. Our culture medium was composed of broth containing 20 per cent horse serum, 2,000 penicillin units per ml. and saccharose added to make up a final concentration of 0·3 *M*. Just after seeding, the

FRACTIONING METHOD FOR L FORMS IN HYPERTONIC MEDIUM

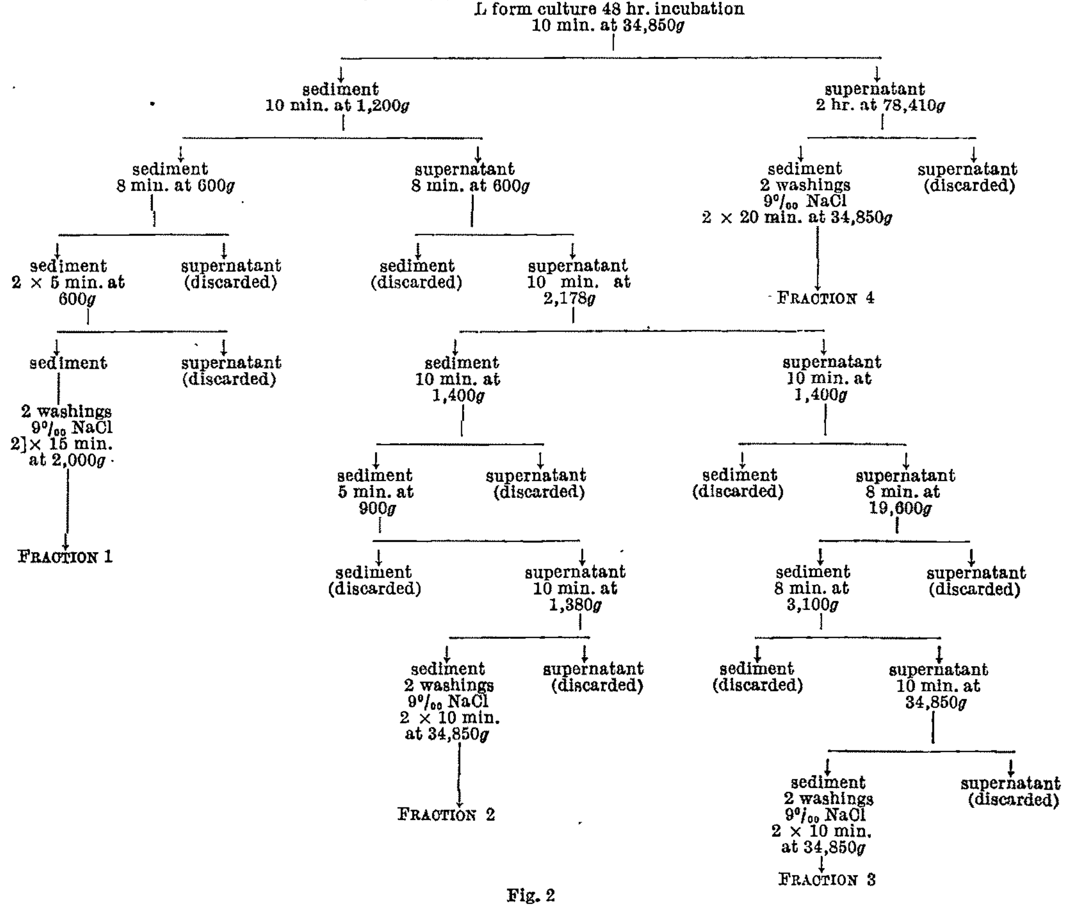

Fig. 2

culture was submitted to vigorous shaking for 30 min., after which it was maintained for 24 hr. at 37° C. Such cultures can easily be transplanted continuously in liquid hypertonic subculture as a normal bacterial suspension. Fig. 1 shows the increase of dry substance plotted against time for one of our cultures suspended in a hypertonic medium, and for a Tulasne culture (films)[2]. The phase of rapid growth in our culture occurs between 18 and 48 hr., whereas in the film cultures the growth takes much longer and reaches its maximum on the fifth day. As regards the morphological aspect, our cultures in hypertonic liquid medium contained large, swollen bodies, 8–12μ in size, as well as small and elementary bodies described by many authors. We have not been able to ascertain the presence of large bodies (20μ) which existed in the original cultures.

The different morphological forms of our cultures were separated by differential centrifugation followed by washings with 0·3 *M* saccharose solution (except where washing with 9 per mille sodium chloride is specified—Fig. 2). The respiration of the different fractions was studied in a Krebs medium with a Warburg apparatus, and the values have been referred to deoxyribonucleic acid (Fig. 3).

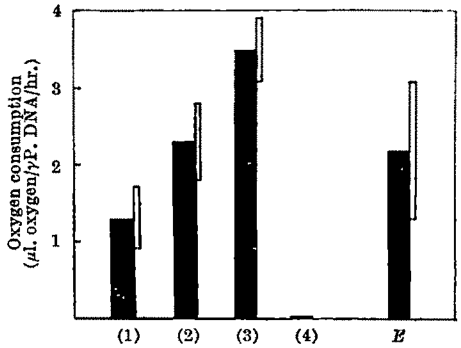

Fig. 3. Oxygen consumption of the various fractions of L forms. Values for large bodies (1), medium bodies (2), small bodies (3), elementary bodies (4) and total culture (*E*)

The results lead us to think that the small bodies of fraction 3, the metabolism of which seems to be most intense, correspond to a state of active proliferation. It appeared also that the oxygen consumption referred to deoxyribonucleic acid was practically nil for fraction 4 (elementary body). It seems to have lost its enzymatic apparatus for the aerobic degradation of glucose.

Supposing that the L forms are representative of a transition from one state to another—that of viruses—the elementary bodies would form a preliminary stage characterized by an already considerable reduction of the enzymatic apparatus of these micro-organisms.

P. Mandel
T. Terranova
M. Sensenbrenner
F. Feo

Institut de Chimie biologique, et
Institut de Biologie Bactérienne,
Faculté de Médecine de Strasbourg,
and
Istituto di Patologia Generale,
Università di Torino.

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BIOLOGY

Changes in Lymphocytes during Antibody Production

During the course of an investigation[1] into the function and life-cycle of lymphocytes, a number of physical techniques were employed to determine the identity of cells isolated from various sources, for example, lymph glands, thoracic duct, thymus, spleen, blood, etc. The average cytoplasmic refractive index of small lymphocytes obtained from the above sites had been determined with a fair degree of certainty. It was noted that in chronically infected rats (rat pneumonia) the small lymphocytes, whatever their source, showed a significantly raised cytoplasmic refractive index. The subcutaneous injection of a particulate antigen (T.A.B.) produced a similar rise preceding but paralleling the rise in the antibody titre of the serum and thoracic duct lymph. We suggest that the refractive index change in the cytoplasm of the small lymphocyte is due to increased protein concentration connected with the mechanism of production of antibodies. A detailed study of this phenomenon is in progress.

K. W. Keohane
W. K. Metcalf

Department of Anatomy,
University of Bristol. Nov. 19.

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Zone Electrophoresis of Rous Sarcoma Virus

The value of zone electrophoresis in the study of animal viruses has been demonstrated by previous workers[1,2]. By this method new criteria for the classification of animal viruses can be obtained. In addition, the study of electrophoretic inhomogeneity of viruses is of special interest. Thus it could be shown for polivirus type I that the virus activity is shared by at least two components with different electrophoretic mobilities[3].

Zone electrophoresis might also be of value for the purification of viruses. In this report, preliminary results of electrophoresis of a cancer virus are given.

The supernatant of Rous sarcoma tissue cultures was chosen as a source of virus. Chicken tissue cultures were infected with Rous sarcoma virus and passaged serially by trypsinization for about two months until almost all cells showed the characteristics of Rous sarcoma cells and the titre of Rous virus in the supernatant was at least 5 log plaque-forming units per ml. The supernatants were then collected and treated by two cycles of centrifugation, one for 10 min. at 5,500*g* and a second for 60 min. at 54,000*g*. In some experiments, hyaluronidase in a final concentration of 7 units/ml. and trypsin in a final concentration of 0·025 per cent were allowed to act on the supernatant for 20 min. at 37° C. before centrifugation. The final pellet was taken up in 0·3 ml. veronal buffer *p*H 8·2 and mixed with an equal amount of 25 per cent cane sugar solution in buffer before introduction into the electrophoresis column. A detailed description of the electrophoresis apparatus and of the electrophoresis technique is given in previous papers[1,2]. Veronal buffer of *p*H 8·2 containing 47·6 gm. sodium diethylbarbiturate and 11·5 ml. *N*/6 hydrochloric acid in 4·3 l. of distilled water was used. Electrophoresis was allowed to proceed at room temperature for 3 hr., with a voltage gradient of 3·5 V./cm. and a current of 20 amp.

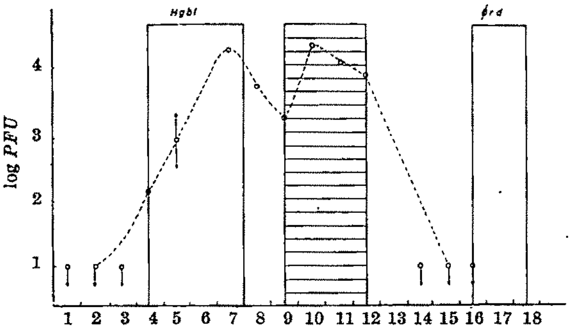

Fig. 1. Zone electrophoresis diagram showing the distribution of Rous sarcoma virus activity in log plaque-forming units (*PFU*) for each consecutive electrophoretic fraction of 0·8 ml. each, indicated on the abscissa. The position of the reference substances are indicated by the first and third vertical column and the opalescent zone containing the impurities by the second vertical column

In the first experiments, rabbit hæmoglobin and phenol red were added as reference substances. In some experiments, decomplemented and defatted[1] horse serum to a final concentration of 0·2 per cent was added to the sugar gradient to stabilize virus activity. The content of electrophoresis column was run out by taking samples of 0·8 ml. each. The virus activity of each fraction was assayed on the chorio-allantoic membrane of the chick embryo by the pock-count method, using 10 eggs per fraction[3].

The migration of the white opalescent initial zone containing a great deal of impurities as judged by electron microscopic analysis[4] could easily be followed against a dark background during electrophoresis. After an electrophoresis of 3 hr., this slightly broadened zone was apparently still compact, the lower part being still white opalescent with a sharp inferior border, whereas the upper part appeared slightly bluish. As can be seen from Figs. 1 and 2, this zone assumes a position intermediate between that of the rabbit hæmoglobin and phenol red under the conditions of the experiment at *p*H 8·2. From the same diagrams, it can be seen that a first peak, representing about 30–50 per cent of the virus activity, separated completely from the principal opalescent zone and migrated slightly faster than rabbit hæmoglobin at *p*H 8·2. As the same finding has been made in similar experiments in which no hæmoglobin was used as reference substance, it must be concluded that the mobility of the first peak of virus activity is independent of the presence of hæmoglobin.

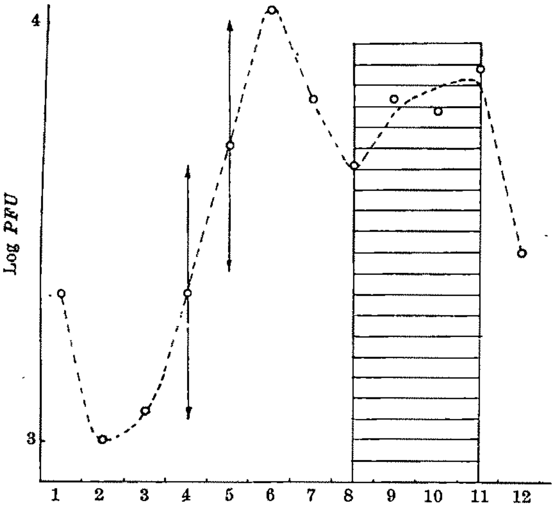

Fig. 2. Zone electrophoresis diagram of Rous sarcoma virus without reference substances. The vertical column represents the opalescent zone. The vertical arrows represent the confidence intervals. *PFU*, plaque-forming units

A second peak of virus activity was confined to the opalescent zone. Only by a further development of the electrophoresis at a low temperature and over a period of more than 3 hr., can it be established whether the virus activity found in this zone can be further separated from the bulk of impurities.

A third, minor peak of virus activity, with a higher mobility than the principal opalescent zone, was found only in some experiments, not discussed in this communication, and will be the subject of further analysis.

Experiments are now under way to establish the significance of the findings in relation to the possible electrophoretic inhomogeneity of Rous sarcoma virus as well as to its purification.

ROBERT CRAMER

Institut de Recherches sur le Cancer Gustave Roussy,
Université de Paris, Villejuif.

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Persistence of Sudanophilic Lipid in Sections of Mummified Tissue

PARAFFIN sections of Egyptian mummy tissues made by various workers[1–4] have shown the appearances of adipose tissue; examinations of mummy tissues by frozen section have been infrequent[3,5]. Shaw[3] failed to detect fat globules in frozen sections of adipose tissue from eighteenth-dynasty canopic material, namely, mesentery and gall-bladder serosa. Lipids have been demonstrated by chemical methods in mummy tissue[6,7] and proved to consist largely of fatty acids with traces of unaltered fat. These fatty acids have been thought to be derived not only from neutral fat but also from protein during the embalming process. Fatty acids and cholesterol have also been demonstrated by chemical methods in remnants of mummy brain[8].

While preparing an Egyptian mummy head for histological examination, it was noted that whitish-yellow material had persisted in the subcutaneous tissues, especially of the scalp, and in the marrow spaces of the calvarium. Frozen-sections of the scalp of the occipital region showed sudanophilia of the subcutaneous and subaponeurotic tissue with a light orange-red colour to a mixture of sudan III and IV and an intense black colour to sudan black. The material was obviously crystalline and proved largely to be plainly birefringent in bundles of thin acicular crystals on examination with polarized light. No red coloration was obtained with nile blue sulphate, and Von Kossa's stain for calcium showed moderate blackening confined strictly to the lipid areas. Sudanophilia and birefringence were reduced after treatment with ethyl alcohol, acetone and more markedly with chloroform and ether. Sudanophilic material which was not anisotropic was noted in small quantities in the remains of sebaceous glands and in small cutaneous nerves, presumably derived from myelin breakdown.

It is known that neutral fats and fatty acids, although mono-refringent in the fresh states, become crystalline on cooling or after fixation in formalin. This phenomenon is frequently seen on storage of animal tissues in formalin and is sometimes very obvious in old museum specimens.

Hunt[9] has described the appearances of the subcutaneous fat in female human bodies remaining in cool, dry surroundings with some air movement in which they would have eventually become naturally mummified. In one body, dead for 50–70 days, the subcutaneous fat spaces contained much granular material which did not dissolve in the usual fat solvents and stained only slightly with sudan black. In the superficial fat were collections of narrow pointed crystal spaces, thought to represent fatty acids. In a further body, dead for about 100 days, fat cells were mostly broken up and replaced by granular material and scanty crystal spaces.

The better preservation of lipid, its crystalline nature and association with calcium in the mummified scalp tissue suggests that some process other than simple dehydration had played a part. It may be that the alkalis used in mummification in Egypt produced some degree of hydrolysis of the neutral fats to fatty acids associated with calcium in the subcutaneous tissues.

My thanks are due to Mr. D. McSeveney for technical assistance.

A. T. SANDISON

Department of Pathology,
The University and Western Infirmary,
Glasgow. Nov. 13.

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In vitro Cultivation of the Histotrophic Stages of *Haemonchus contortus* and *Ostertagia* spp.

LAPAGE[1] working with *Haemonchus contortus* reported in 1933 that: "Attempts have been made to cultivate the parasitic larval stages, a method having been found by which the free-living infective third stages may be exsheathed and sterilized, so that the first parasitic stages may be obtained and studied further in sterile media of known composition. Although these first parasitic stages have been studied in hanging drops in more than 200 media designed to imitate environmental factors to which parasites are presumably exposed in the body of the host no success has been obtained".

Stoll[2] found that exsheathed sterile *H. contortus* infective larvæ underwent the first parasitic ecdysis when maintained in various balanced salt solutions. Apart from the formation of a buccal cavity, no growth or differentiation occurred and the larvæ died soon after ecdysis occurred.

Weinstein and Jones[3] were the first to culture successfully *in vitro* the histotrophic stages of a parasitic worm, and in fact produced sexually mature adults of *Nippostrongylus muris*. Attempts by these workers to culture the parasitic stages of *Strongyloides* spp. were not successful, even in media in which *N. muris* had developed to adults[4].

In this department early attempts failed to culture *H. contortus* and *Ostertagia* spp. parasitic stages in the medium described by Weinstein and Jones. As a result, a programme was undertaken systematically to test, separately and in combination, the various nutrients which previous workers had found to support *in vitro* growth of nematodes. The components included chick embryo extracts, Hela cell cultures, various liver extracts, sodium caseinate, casein hydrolysates, serum, Tyrode solutions and various balanced salt solutions used in tissue culture methods. Various static and roller tube culture methods were tested, most media being set up under both conditions. The effect of transfering media on successive days was also investigated.

Success was eventually obtained with a medium, now in regular use, consisting of chick embryo extract, autoclaved sheep liver extract, casein hydrolysate and sheep serum in a 2 : 2 : 2 : 1 ratio. This is remarkably similar to the medium recommended by Weinstein and Jones, but differs in the mode of preparation of the liver extract. In this medium, using a roller tube technique, growth and metamorphosis of larval stages occurs up to the adult stage in about 24–30 days. By this time, however, the individuals have become recognizably stunted. The media require changing every 72 hr. for the first 12 days.

Re-investigation of the cause of the early failure suggests that the original fresh liver extract contained a lethal factor, and it appears that the nutrient factors in fresh liver are subject to considerable variation. The method of liver preparation now in use is that described by Nicholas[5], with the difference that only a single sterilization by autoclave is made.

PAUL H. SILVERMAN*

Department of Parasitology,
Moredun Institute,
Edinburgh, 9. Nov. 7.

* Present address: Veterinary Research Division, Allen and Hanburys, Ltd., Ware, Hertfordshire.

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Effect of Gibberellic Acid on Length and Number of Epidermal Cells in Petioles of Strawberry

INCREASE in height is perhaps the most widely observed effect of gibberellic acid on plants. This is mainly due to longer internodes, and not to a larger number of nodes. The increased length of an internode has been variously ascribed to increases in numbers of cells, increases in length of cells and to both. Stowe and Yamaki[1], reviewing earlier (especially Japanese) work, conclude that "cell elongation in most cases seems to predominate as the result of gibberellin application". Since then Greulach and Haesloop[2] could find no significant increase in size of cell when the lengths of internodes of *Phaseolus vulgaris* were increased by a mean of 2·28-fold by the application of gibberellic acid. They concluded that cell division had been promoted. Further information is clearly desirable. In the strawberry plant, height is determined mainly by the length of the leaf petioles. The results presented in this communication show that increases in length of petiole brought about by the application of gibberellic acid involve increases both in the number and the length of cells in the epidermis.

Plants of the variety Redgauntlet were grown in pots in two growth cabinets at 60° F. in a 12-hr. photoperiod. The cabinets were illuminated at two different intensities (about 800 and about 1,200 foot candles) with equal numbers of 'Warm White' and

Table 1

Treatments and treatment differences	Length of petiole (mm.)	Mean length of cell (μ)	Calculated No. of cells
High light intensity	165·6	111·8	1,472
High light + G.A.	224·6	132·0	1,695
Increase due to G.A.	59·0	20·2	223
S.E.D.	±20·5	±7·6	±102·7
Increase due to G.A. (per cent)	35·6	18·1	15·1
Low light intensity	231·0	129·6	1,782
Low light + G.A.	261·8	138·6	1,892
Increase due to G.A.	30·8	9·0	110
S.E.D.	±20·5	±7·6	±102·7
Increase due to G.A. (per cent)	13·3	6·9	6·2
Overall mean increase due to G.A.	44·9	14·6	166·5
S.E.D.	±14·5	±5·4	±72 6
Increase due to G.A. (per cent)	22·7	12·1	10·2

G.A., gibberellic acid.

'Northlight' fluorescent lamps supplemented with tungsten filament lamps. Following an initial application of 16 μgm. per plant on June 18, gibberellic acid was applied in aqueous solution at the rate of 8 μgm. per plant twice weekly until August 12. The solution was applied in single drops of 0·1 ml. which were immediately covered with cover slips. The drops were absorbed in about 24 hr. It is possible that some loss of activity occurred during this period. This level of treatment gave the moderate increases in length of petiole thought to be desirable for this investigation and avoided gross morphological changes such as can be obtained with larger doses. There were five treated and five untreated plants in each growth cabinet.

On August 14 the petioles were measured from the point of insertion of the stipulary leaf bases to the conjunction of the laminæ. The second leaf to emerge on each plant after the commencement of treatment was selected for cell measurement. Leaves in this position on the stem were fully extended and also showed a substantial effect of treatment. The petioles were preserved in 50 per cent alcohol. For cell counts the petioles were removed from the alcohol and soaked in water over-night. Narrow strips of epidermis were peeled away from nine separate, equally spaced locations on each petiole. After clearing in lactic acid the strips were mounted in glycerine and inspected under the microscope. The image was projected on to a ground-glass screen for cell measurement. The cells were measured in tandem pairs, five pairs being measured at random in six different fields for each of the nine locations, making a total of 540 cells measured on each petiole. Guard-cell areas were deliberately avoided. Mean length of cell was obtained for each petiole, and this, divided into the length of petiole, gave a figure for 'number of cells' for each petiole.

Lengths of petioles, mean lengths of cells and the calculated figures for 'number of cells' were statistically analysed and the standard errors are tabulated together with the results. Percentage increases were calculated separately for length of petiole and the two component factors.

Significant differences between treated and untreated plants were obtained at the higher light intensity. At the lower intensity the differences were about half those at the higher, and were not significant. The overall effect of gibberellic acid at the two light intensities was a significant increase in length of petiole, composed of a significant increase in both mean length of cell and mean calculated number of cells. The percentage figures suggest that the increase in length of petiole was contributed to more or less equally by increases in both components.

The lesser effect of gibberellic acid at the lower light intensity is noted; but, as this work forms part of a broader investigation into the effect of a number of environmental factors on length of cell and number as components of length of petiole, a discussion of this and of the effect of light intensity is held over for another occasion.

We wish to thank Dr. M. R. Sampford for advice on the statistical treatment of the data, Mr. J. Stewart and Miss Kamala Saggar for measuring the cells, and Plant Protection, Ltd., for supplying the gibberellic acid.

C. G. GUTTRIDGE
P. A. THOMPSON

Scottish Horticultural Research Institute,
Mylnefield, Invergowrie by Dundee.
Nov. 14.

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Effect of Residual House Spraying in the Plains on Anopheline Densities in Huts on the Pare Mountains

AN experiment is in progress in the Pare area of Tanganyika to find whether or not malaria can be controlled by residual treatment of huts with dieldrin. The area is 3–4,000 square miles, involving a population of 100,000. The Pare Mountains extend along the length of the treated area, at an altitude of about 4,000 ft. above sea-level. The population is about equally divided between the malarious plains and the mountains, which are separated by a steep escarpment. Surveys of the human population did not suggest that active transmission occurred on the mountains[1]. Huts were treated only in the plains, and the first cycle of spraying was completed in November 1955. Subsequent treatments continue at intervals of 8 months.

The majority of the mountain population live at about 2,000 ft. above the plains; but villages occur on the sides of the mountain in a few areas where the escarpment is less steep. Spray catches were made in four villages above the escarpment, and in one village half way up it. Spray catches were also made at the foot of the mountain, in the area that was eventually treated with dieldrin. The results are shown in Table 1.

Above the escarpment, before residual spraying, there were very low densities of *A. gambiae* in huts and *A. funestus* compared with those at the foot of the mountain, but half-way up there was a substantial infestation of huts by *A. funestus* in May. After residual spraying, *A. funestus* disappeared from huts on the mountains as well as in the plains, and densities in huts of *A. gambiae* were also reduced.

These findings suggest that the presence of *A. gambiae* and *A. funestus* in huts on the mountains is dependent on direct infestation from the plains, followed to some extent also by seasonal reinfestation of breeding places, as *A. gambiae* was found breeding in a rice field on the mountains before residual spraying was carried out. Garnham[2] has discussed the factors that give rise to malaria transmission at high altitudes, and has shown how malaria, largely absent in the highlands of Kenya before the First

Table 1. Densities of *A. gambiae* and *A. funestus* in Huts at Different Levels in the Pare District

	Before dieldrin					After dieldrin									
	1955					1956					1957				
	Jan.	April	May	July	Oct.	Jan.	April	May	July	Oct.	Jan.	April	May	July	Oct.
Untreated huts 2,000 ft. above valley (20–24 huts)															
A. gambiae	0·3	0·6	0·2	0	0	0·2	0·2	0	0	0	0·5	0	0	0	0
A. funestus	0·1	0·1	1·9	0·5	0·7	0	0	0·05	0	0	0	0	0	0	0
Untreated huts 1,000 ft. above valley (5–6 huts)															
A. gambiae	0	5·0	0·3	0	0	0·7	0·2	0	0	0	0·8	0	0	0	0
A. funestus	0	3·2	39·5	8·5	0	0·2	0	0	0	0	0	0	0	0	0
Treated huts at foot of escarpment (8–24 huts)															
A. gambiae	35	13	19	2	2	3·0	2·2	0·1	0	0·13	2·0	0·5	0·1	0·75	0
A. funestus	2	24	75	28	2	0·1	0	0	0	0	0	0	0	0	0

World War, and the development of roads and agriculture, have increased concurrently. On the Pare Mountains, roads are relatively undeveloped, and motor transport is, and was, virtually absent in this area. It is probably the strong winds, blowing up from the Mkomazi valley, that are chiefly responsible for carrying the mosquitoes into the mountains. Mosquito densities in huts suggest that some transmission was occurring in a few villages on the upper slopes of the Pare Mountains before huts in the plains were treated with dieldrin, although little or none occurred above the escarpment. Residual spraying in the plains greatly reduced anopheline infestation in huts on the mountains, and has therefore indirectly protected the inhabitants from the risk of malaria infection.

I am indebted to Mr. J. D. Phipps for his help during the three years of observations, and to Dr. D. Bagster Wilson for valuable criticism.

A. Smith

East Africa Institute of Malaria
and Vector Borne Diseases,
Amani, Tanganyika.
Nov. 3.

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Paper Electrophoretic Separation of the Proteins of Some Leguminous Seeds

The plant materials examined during this work were acetone powders prepared from lentils (*Lens esculenta*, Moench), 'horse' beans (*Vicia faba*, L.), lupin seeds (*Lupinus termis*, Forsk) and fenugreek seeds (*Trigonella foenum-graecum*, L.). Each acetone powder was extracted separately with 0·1 *N* borax–phthalate buffer at *p*H 8·0, the proportion being 10 gm. of acetone powder to 60 ml. of buffer. Extracts obtained in this way were subjected to paper electrophoresis on Whatman No. 1 filter paper in a Shandon horizontal tank. Borax–phthalate buffer, which was prepared by mixing 0·1 *N* borax and 0·1 *N* potassium hydrogen phthalate (*p*H 8·0), was used. A potential of 150 V. was applied for 12 hr. The protein bands were dyed with azocarmine *B* solution according to Turba and Enenkel's method[1].

Four coloured bands (designated *A–D*) appeared in the electrophoretic pattern of each of the seed extracts. It was possible, by the use of ammonium sulphate fractionation, to isolate each of the proteins *B*, *C*, and *D* from the extract of lentil seed. Each of the protein fractions was re-precipitated 2–3 times and each of the final precipitates was dissolved in a small volume of borax-phthalate buffer and dialysed against the same buffer. These protein fractions were tested electrophoretically along with a sample of the original extract.

Protein fraction *D* (precipitated in the range 45–54 per cent saturated ammonium sulphate) was orange-red in colour and fluorescent in ultra-violet light. The absorption spectrum was read with a Hilger spectrophotometer and showed maxima at 360, 460 and 550 mμ (Fig. 1), which indicates that this protein is a flavoprotein.

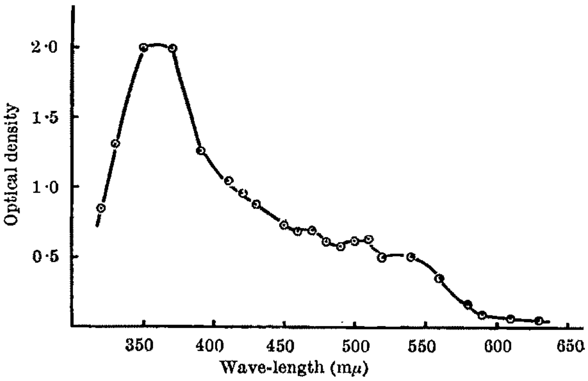

Fig. 1

In order to determine the percentage of each of the protein constituents the filter paper was cut (in a direction perpendicular to the flow of the current) into strips 0·5 cm. wide. Each of the small strips was eluted separately with 5 ml. 10 per cent ammonium hydroxide. The optical density of each extract was determined with a Unicam colorimeter using a filter (Ilford No. 303). By plotting optical density reading against the distance from the point of application of the protein extract to the strip an electrophoretic pattern was obtained. By means of a planimeter, the area under each peak was measured, and in this manner the percentage of the different proteins (in relation to the total proteins in the extract) was assessed. The results (Table 1) indicate that, although the extract of each of the four kinds of seeds under investigation contains the four fractions, the percentage of each of the proteins varies according to the type of seed.

Table 1. Amounts of Various Proteins in Some Leguminous Seeds

Seed	Protein			
	A	*B*	*C*	*D*
Lupinus termis	1·89	86·55	8·79	2·75
Trigonella foenum-graecum	5·26	84·27	5·26	5·26
Vicia faba	5·11	46·51	40·23	8·13
Lens esculenta	3·91	71·02	7·57	17·49

Esam M. Moustafa

Department of Agricultural Chemistry,
University of Khartoum,
Sudan. Nov. 14.

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Density-Dependent Factors in Ecology

Solomon and Varley[1] did well to direct attention to the confusion that accompanies the ecological term 'density-dependent factors'. Howard and Fiske's[2] original idea that the multiplication of natural populations of animals can be restricted only by some "factor" that exerts "a restraining influence which is relatively more effective when other conditions favour undue increase" has been extended in a number of directions. I would like to add to Solomon and Varley's etymological criticism of the usage of the term my own criticism of the fruitfulness of the ideas implicit in the term.

It has been argued that only 'biotic factors' can qualify for the class 'density-dependent factors' and hence only competition can limit the numbers of natural populations. Howard and Fiske[2] and Smith[3] qualified this argument but Nicholson[4], and Elton and Miller[5] were more specific. When I tried to confirm the statement by examining the case-histories of a number of populations the ecology of which had been described, I found that there was little correlation between biotic factors and density-dependent factors[6]. The concept of density-dependent factors has also been used as a starting point for mathematical models. The well-known models of Lotka[7] and Volterra[8] have been partly confirmed by laboratory experiments with such simple animals as *Paramecium* but not with more complex ones such as *Calandra* and *Tribolium*, and not with any sort of animal in Nature[9].

Nicholson[10] has published an elaborate mathematical treatment that purports to cover natural populations. His model rests upon the idea of 'equilibrium density' which is analogous to the concept of the 'singular point' in the Lotka–Volterra models. For example, his equation for intraspecific competition, which is one of three basic equations that form the foundation for his model, reads:

$$N_E = \frac{g - lg - wg}{q}$$

where g is the rate of replacement of the 'governing requisite', l is the proportion lost to extraneous influences, w is the proportion lost to individuals that fail to complete the life-cycle through crowding, q is the amount required by one individual to complete its life-cycle and N_E is the equilibrium density.

The value of w depends on the density of the population; above a certain ceiling of density w may be 1; below a certain threshold it may be 0. Solving the equation for values of w between 1 and 0 gives values of N_E between 0 and $\frac{g - lg}{q}$. This does not satisfy the concept of an equilibrium density. On the other hand the equation may be written:

$$N = \frac{g - lg - wg}{q}$$

where N is defined as the density of the population. Then a particular value of N, say N_E, may be designated such that it corresponds to an arbitrary value of w, say w'. But in Nicholson's model the value of w' is defined in terms of N: w' is the value of w which gives $N = N_E$ and there is no other way of defining it. Thus the equation is a tautology. The other two basic equations are subject to similar criticism.

Milne[11] and Nicholson[10,12] argued that only density-dependent factors can keep a population from becoming extinct because, as Elton[13] put it, "the control of populations, i.e., the ultimate upper and lower limits set to increase, is brought about by density-dependent factors". Now if we do an experiment to test a particular null hypothesis such as "this population of species x will not be extinguished by n hours exposure to $t°$ C" we may consider that the negative hypothesis has been disproved if the population is observed to be extinct after we have treated it in this way. (See Fisher's[14] discussion of the null hypothesis.) But if the population remain extant after the experiment we cannot reasonably argue that the population was kept extant by exposure to $t°$ C. for n hours; similarly, with all other environmental components, including density-dependent factors. Moreover, because the argument that only density-dependent factors can keep a population extant depends on the concept of 'ultimate limits' it is not possible to specify a definite time in the null hypothesis that stems from this proposition; this implies that experiments must be continued indefinitely if the null hypothesis is to be disproved[6]. For these two reasons this argument has stultified experiment.

In science an idea may be judged fruitful if it leads to experiment and observation which extend our understanding of Nature. By this criterion the idea of 'density-dependent factors', like the idea of vitalism, seems to have been remarkably fruitless.

H. G. ANDREWARTHA

Unit of Animal Ecology,
Department of Zoology,
University of Adelaide.
Nov. 7.

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Preparation and Sectioning of Tissues embedded in 'Araldite' for Electron Microscope Examination

OWING to the complete lack of polymerization damage and less-stringent hardening conditions, 'Araldite' is being increasingly used as an alternative to butyl methacrylate as an embedding medium in the preparation of tissue for study in the electron microscope. Unfortunately, it has one serious drawback of its own. Unless the consistency of the plastic falls within fairly narrow limits, serious wrinkling is found on sectioning which may make the specimens quite unsuitable for study.

The 'Araldite' components used in the embedding mixture are: 'Araldite' casting resin M, 'Araldite' hardener 964*B*, and 'Araldite' accelerator 964*C*. Dibutyl phthalate is used as a plasticizing agent.

Originally a mixture of casting resin 10·0 ml., hardener 10·0 ml. and plasticizer was used for the initial shakings after fixation in osmic acid and dehydration in alcohol. Soaking times at 48° C. were 3 hr. in a mixture of ½ absolute alcohol, ½ 'Araldite', followed by three soakings of 3 hr. each in 'Araldite' alone. 0·4 ml. accelerator was then added to the mixture and the tissue was left to soak at room temperature for 12 hr. before the final embedding at 48° C. in accelerated 'Araldite'. The capsules were hardened at 48° C. for about 72 hr. before cutting.

It was early found that even a moderate increase in the concentration of accelerator produced a very hard and brittle block. It was possible to produce thin sections from such a block, but they invariably showed severe wrinkling, and it is now usual to discard any blocks which are found to be brittle during preliminary trimming. Reduction of accelerator produced plastic of a consistency that would cut without wrinkling, but this only applied to the supporting block. The tissue itself was often exceedingly soft and pasty, and it was obvious that the 'Araldite' had not penetrated in desirable concentrations. As it was known that the tissue could be hardened by additional accelerator it was suspected that the casting resin rather than the hardener was failing to penetrate, and this view was supported by the fact that the hardener is by far the less viscous of the two. As a result the soaking times were greatly prolonged, and the concentration of the casting resin in the early mixtures was increased. The concentrations used in the first soakings are now : casting resin 15 ml., hardener 5 ml., plasticizer 1 ml. After fixing and dehydration the tissue is soaked at 48° C. in a mixture of ½ absolute alcohol, ½ 'Araldite' for 6 hr., and then in pure 'Araldite' for 72 hr., the mixture being changed every 24 hr. The soaking is then continued for another 72 hr. in a mixture of casting resin 10 ml., hardener 10 ml. and plasticizer 1 ml., the resin again being changed every 24 hr. 0·3 ml. accelerator is then added for a 24 hr. soak at room temperature followed by the final embedding in a fresh accelerated mixture. With only 0·3 ml. accelerator hardening times at 48° C. are increased, and it is not unusual for the blocks to require baking for a week before they are suitably hard. Even now preliminary trimming may show the tissue to be undesirably soft, but further baking of the untrimmed capsules produces little improvement. If, however, the block is trimmed to expose the tissue in a small pyramid of soft plastic, further baking at 48° C. for 2–3 days will cause satisfactory hardening to a cutable consistency.

This embedding procedure has been successfully used on a variety of tissues, including pituitary, liver, various tumours, and striated muscle ; but even now it is rare to produce sections without a trace of wrinkling. Birbeck and Mercer[1] found that a narrow knife angle and very slow passage of the block across the blade would reduce wrinkling, as would the reduction of the cutting area of the block to very small dimensions. This has also been our finding, but with 'Araldite' it is often possible to obtain thin sections of up to 1 mm. square, and the increase in viewable tissue area is a great advantage. In these conditions, it is usually found that the portions of the section cut last show wrinkling, but this can largely be counteracted by trimming the block to rectangular shape and cutting with one long side to the blade.

During the period of this work I was in receipt of a grant from the British Empire Cancer Campaign.

J. M. Davis

Department of Radiotherapeutics,
University of Cambridge.
Nov. 13.

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A Simple Micro-Stirrer

A simple micro-stirrer has been developed for micro-analyses involving quantities of fluid varying from 1 ml. down to small drops of fluid which are titrated on waxed slides. Its main advantages over previous methods of micro-stirring are that it is cheap and relatively simple to make and can be controlled to give almost instantaneous even mixing without splashing or bubbling. It is therefore particularly suitable for continuous stirring while performing potentiometric or colorimetric titrations.

The stirrer (Fig. 1) consists of an electric bell assembly driven by means of a small domestic bell transformer which is tapped to give 3, 5 and 8 volts. For potentiometric titrations the bell is removed and a piece of stiff piano wire is attached to the hammer arm by means of a tight-fitting polyethylene sleeve. The piano wire is flattened at the sleeve end to prevent it turning and is then bent downwards through an angle of 90°. A piece of 'Tufnol' insulates the wire from the bell mechanism. The other end of the piano wire carries a small chuck, which holds a paddle-shaped electrode.

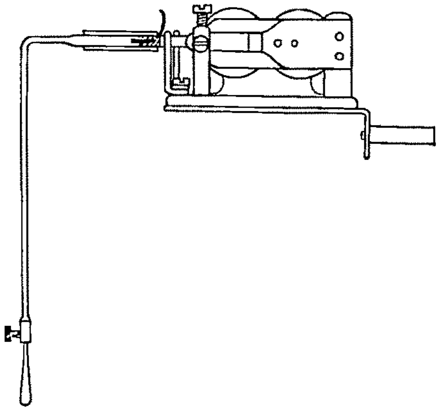

Fig. 1

Even and splashless stirring is obtained by limiting the travel of the hammer arm by means of two movable stops, one on each side of the arm. The high-frequency vibrations are transmitted and amplified by the whip of the stirring arm, the lateral vibrations of which should be very small to obtain the desired type of stirring. The amplitude of these vibrations is controlled by the length and stiffness of the wire, while their frequency can be altered by varying both the voltage energizing the bell and the setting of the interruptor set screw. For colorimetric titrations, particularly those carried out in an absorptiometer, a small glass paddle is recommended.

R. Morris

Department of Zoology,
University of Nottingham.
Nov. 18.

Salt Excretion in Marine Birds

May I add a further observation to F. S. Russell's interesting communication under this title[1] ? More than thirty years ago I noticed a similar thing in the giant petrel or stinker (*Macronectes giganteus*) of the southern oceans, and published[2] an account of it, though not in a scientific paper, in 1951 : "When [a flying stinker] is right alongside and you can see him plainly, nearly always you will notice that he has a drop on his nose ; hanging from the tip of the hook at the end of his beak is a drop of something—whether water or some other fluid I know not". This, too, was evidently salt excretion in action.

L. Harrison Matthews

Zoological Society of London,
Regent's Park,
London, N.W.1.

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PSYCHOLOGY

Colour Vision Phenomenon of a New Class

If one looks toward a bright field of white light (white cloud or white fluorescent lamp), interposes an orange Wratten No. 21 filter for 5 sec., then removes the filter, a bright, saturated greenish-yellow pattern is seen. It is of irregular, blotchy shape and persists for 1–2 sec.

The hue and saturation of the pattern remain unchanged despite wide variation in choice of filter used in step 1. (Step 1 is the 5-sec. period in which an orange filter or the equivalent is used ; step 2 is the 1–2-sec. period in which the pattern is seen.) Instead of the orange Wratten 21 filter, any filter that transmits much 540–590 mμ light and no light of wave-length below 490 mμ may be used.

In step 2, instead of using no filter, any blue, green, yellow, orange, purple or grey filter that has appreciable transmittance near 470 mμ may be interposed.

To predict whether a filter will succeed in step 1, the spectral transmittance curve of the filter must be examined. The colour of the filter may not be indicative. (I have a pair of orange filters that are almost identical in colour but behave oppositely, one succeeding in step 1 and the other in step 2.)

Moderately high intensity is required in step 1. The intensity of a white cloud or a bare white fluorescent lamp is very satisfactory. A heavily overcast sky, or a sheet of white paper resting on the top of a desk, may be too dim.

The intensity and quality of the step 1 illumination determine whether the pattern will be seen (in the subsequent step), but do not govern the brightness or colour of the pattern.

It is the step 2 illumination that governs the brightness and colour of the pattern. If the step 2 illumination consists of white light, the pattern appears greenish-yellow, and the brightness is roughly proportional to the intensity of the white light. If the step 2 illumination consists of just 400–500 mμ light, the pattern appears green. If the step 2 illumination contains 400–500 mμ light and also light in longer wave-length bands, the hue appears intermediate between green and the hue one normally associates with the longer wave-length bands. For example, the illumination obtained with the aid of a white fluorescent lamp and a reddish-purple filter transmitting in the two bands 400–500 mμ and 600–700 mμ leads to a pattern that is midway between green and red, namely, orange.

If the step 2 illumination is of zero intensity, the pattern does not appear. (Various after-images appear, but seem unrelated to the pattern under discussion.)

The pattern has an irregular, blotchy shape, and very different shapes may be noticed in successive trials. The size of the pattern may decrease markedly from one trial to the next, and, after four or five trials made within a period of one minute, the pattern may entirely fail to appear. In the first trial the pattern may have an angular width of 40–80 deg., and the fovea and macula regions may participate ; in subsequent trials the pattern becomes less extensive, and the fovea and macula regions may fail to participate. The grain size, or resolution, of the pattern is low, being perhaps 0·1–0·5 deg.

After resting his eye for 10 min. the observer may see the phenomenon again. Resting does not require dim light or darkness ; it requires merely the avoidance of light that is devoid of energy in the 400–500 mμ range. Looking through any step 1 filter is tiring, but looking through any step 2 filter is not. Thus tiring, too, depends on the transmittance curve of the filter rather than on its colour.

In the first trial (that is, when the eye is fresh), the duration of step 1 may be reduced ; the 5-sec. duration is not necessary, and durations as short as 2 sec. (sometimes even ½ sec.) suffice. Moreover, the intensity of the pattern afterwards seen is independent of the step 1 duration.

When the pattern disappears (after 1–2 sec. of step 2 illumination), it does not fade gradually and uniformly, but disappears piecemeal, each piece disappearing suddenly.

Each eye acts independently. One eye may become tired and the other (not exposed to step 1 illumination) may remain fresh. Indeed, the different regions of a single eye appear to act independently. Accordingly, split-field experiments are feasible. For example, in step 2 the patterns produced by two unlike filters held side-by-side a few inches in front of the eye may be compared.

A blue or magenta pattern is sometimes observed in step 1 if this step is prolonged for 5–15 sec., and this pattern sometimes has a shape similar to that of the pattern afterwards appearing in step 2. (I am indebted to my colleague E. S. Emerson for pointing this out.)

Approximately fifty of my friends have tried to see the greenish-yellow pattern by the method indicated in the first paragraph, and more than forty succeeded.

The new phenomenon has little in common with the usual adaptation, fatigue, or complementarity phenomena. Such phenomena usually involve smooth fields, dim and unsaturated colour, slow build-up and gradual fading. Also, the hues perceived usually change when the hues of any of the exciting fields are changed, and they are similar when exciting fields are similar in colour. The new phenomenon exhibits very different tendencies which are suggestive of abrupt switching mechanisms.

William A. Shurcliff

Research Laboratory,
Polaroid Corporation,
Cambridge, Mass. Oct. 21.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 19

Royal Geographical Society (at 1 Kensington Gore, London, .W.7), at 5 p.m.—Prof. A. L. Banks: "The Study of the Geography f Disease".

Institution of Electrical Engineers, Radio and Telecom- unication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—r. A. H. W. Beck: "High-Current Density Thermionic Emitters".

University of London Institute of Education (in the Assembly all, Malet Street, London, W.C.1), at 5.30 p.m.—Dr. W. Mays: Piaget's Theory of Intellectual Development".*

British Computer Society (at the Northampton College of dvanced Technology, St. John Street, London, E.C.1), at 6.15 p.m. -Mr. D. C. Hemy: "The Study of the Application of a Computer Production Control".

Institute of Metal Finishing (at Northampton College of Ad- anced Technology, St. John Street, London, E.C.1), at 6.15 p.m.—r. P. Eisler: "Printed Circuits—Some Metal Finishing Methods sed on Foil-Clad Laminates in Electronic Production".

Royal Institute of Chemistry, London Section (at Enfield echnical College, Queensway, Ponders End, Enfield), at 7.30 p.m.—r. A. S. Curry: "The Chemistry of Poisoning".

Monday, January 19—Thursday, January 22

Physical Society (at the Royal Horticultural Society's Old and ew Halls, Westminster, London, S.W.1)—Exhibition of Scientific struments and Apparatus.

Discourses:

onday, January 19

At 5.45 p.m.—Mr. R. S. Pease: "The Physics of Controlled Thermo- uclear Fusion".

uesday, January 20

At 5.45 p.m.—Dr. Robert Page: "Frontiers of Space".

Vednesday, January 21

At 5.45 p.m.—Mr. J. G. D. Pratt: "Physical Science in the Trans- ntarctic Expedition", introduced by Sir Vivian E. Fuchs.

Tuesday, January 20

Bone and Tooth Society (at the Institute of Orthopædics, 234 reat Portland Street, London, W.1), at 4.30 p.m.—Symposium on Epiphysial Growth".

British Museum (Natural History) (in the Chemistry Lecture heatre, Imperial College of Science and Technology, Exhibition oad, London, S.W.7), at 5.30 p.m.—Dr. Isles Strachan: "Darwin d Palæontology" (Swiney Lectures on Geology).* (Further lectures January 22, 27, 29, February 3 and 5.)

Institution of Electrical Engineers, Measurement and ntrol Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—iscussion on "D.C. Amplifiers" opened by Mr. K. Kandiah.

British Glaciological Society (at Bedford College, Regent's rk, London, N.W.1), at 6 p.m.—Prof. R. Finsterwalder (Munich): he International Glaciological Expedition to Greenland".

Plastics Institute, London and District Section (at the Well- me Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m. Prof. M. G. Stacey, F.R.S.: "Fluorine Containing Polymers".

Wednesday, January 21

Royal Society of Arts (at John Adam Street, Adelphi, London, .C.2), at 2.30 p.m.—The Right Hon. Lord Nathan, P.C.: "Tech- cal Education—a Prognosis".

Royal Meteorological Society (at 49 Cromwell Road, London, W.7), at 5 p.m.—Mr. F. A. Berson: "Some Measurements on ndercutting Cold Air"; Mr. R. A. Hamilton: "The Meteorology North Greenland During the Mid-Summer Period" and "The eteorology of North Greenland During the Mid-Winter Period".

Royal Statistical Society (at the London School of Hygiene d Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), 5.15 p.m.—Mr. K. S. Lomax: "Production and Productivity ovements in the U.K. since 1900".

Institution of Electrical Engineers, Radio and Telecom- nication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—r. C. G. Garton: "Dielectric Materials—Trends and Prospects".

Institution of Mechanical Engineers, Applied Mechanics roup (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m. Discussion on "Trouble with Vibration".

Royal Institute of Chemistry, London Section (joint meeting ith the London Section of the Society of Chemical Industry, University College, Gower Street, London, W.C.1), at 6.30 p.m.—Eric Rideal, F.R.S.: "The Impact of Colloid Science on Tech- logy".

Society of Chemical Industry, Food Group (joint meeting with e Oil and Fats Group, at Brunel College, Acton), at 7 p.m.—of. A. C. Frazer: "The Biological Effects of Polyoxyethylene sters".

Thursday, January 22

University College (in the Anatomy Theatre, Gower Street, ndon, W.C.1), at 1.15 p.m.—Mr. B. C. Brookes: "The Limits of e Popularization of Science".*

University College, Department of Biochemistry (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Prof. F. G. Young, F.R.S.: "Hormones and Metabolic Processes"*. (Further lectures on January 29 and February 5).

Thursday, January 22—Friday, January 23

Institute of Physics (in collaboration with the British Nuclear Energy Conference, in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, London, S.W.1), at 2.30 p.m. on Thursday and 9.30 a.m. on Friday—Symposium on "Nuclear Fuel Cycles".

Friday, January 23

British Psychological Society, Occupational Psychology Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. M. J. Kirton: "Some Aspects of Current Research on Management Initiative".

Biochemical Society (in the Department of Chemistry and Bio-chemistry, St. Thomas's Hospital Medical School, London, S.E.1), at 2 p.m.—379th Meeting.

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 2.15 p.m.—Geophysical Discussion on "The Automatic Reduction of Geophysical Data". Chairman: Sir Edward Bullard, F.R.S. Speakers: Mr. G. A. Corby, Mr. A. Dennison, Mr. G. W. Lennon, Mr. R. H. Merson, Mr. C. M. Minnis and Mr. M. J. Tucker.*

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. H. R. Howells: "Marine Refrigeration" (Thomas Lowe Gray Lecture).

Manchester Statistical Society, Industrial Group (in the Portico Library, 57 Mosley Street, Manchester), at 6 p.m.—Dr. M. G. Simpson: "Operational Research in the Coal Industry".

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Inaugural Meeting of the Institution's Medical Electronics Group. Address by Prof. A. V. Hill, F.R.S.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Keeper (with a university degree or the Diploma of the Museums Association, specialized in some branch of zoology or botany, a wide general knowledge of natural history, and preferably experience of museum work) of the Department of Biology—The Director, Museum and Art Gallery, New Walk, Leicester (January 31).

Lecturer in Biochemistry—The Secretary of University Court, The University, Glasgow (January 31).

Research Assistant in the Department of Physics for post-graduate studies in electron diffraction and microscopy, leading if desired to a higher degree—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (January 31).

Senior Lecturer in Mechanical Engineering—The Registrar, The University, Sheffield (January 31).

Senior Lecturer (with a good honours degree and teaching experience) in Applied Mathematics, and Lecturers (2) (with a good honours degree and teaching experience) in Mathematics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (February 4).

Senior Lecturer or Lecturer (with special qualifications in pure mathematics) in Mathematics—The Registrar, The University, Manchester 13 (February 7).

Chair of Microbiology in the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 12).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Engineering, Pharmacology or Physics—The Secretary, The University Aberdeen (February 13).

Senior Lecturer in Obstetrics and Gynæcology at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, February 15).

Lecturer (preferably interested and with research experience either in Western industrial societies or in Africa) in Anthropology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

Lecturer (with an honours degree in geography) in Geography at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

Senior Lecturer in the History and Philosophy of Science at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

Halliburton Chair of Physiology tenable at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 17).

Lecturer in Philosophy at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 20).

Demonstrator (with interests in human geography, preferably economic geography) in the Department of Geography—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (February 21).

Lecturer in Applied Mathematics (Digital Computing)—The Secretary, The Queen's University, Belfast (February 28).

Chair of Veterinary Medicine or Chair of Veterinary Surgery, in the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 9).

Research Fellow or Fellow in the Department of Statistics, Research School of Social Sciences, Australian National University, Canberra, to work in the field of mathematical statistics and its applications to other sciences—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 16).

Chair of Philosophy in the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 31).

Senior Lecturer in Physics at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 31).

Assistant Professor of Biology, to give instruction in physiology, embryology and histology—The Head, Department of Biology, Memorial University of Newfoundland, St. John's, Newfoundland.

Graduate Physicists (with a first or good second) for research into either (*a*) the solution of scientific and technical problems by the use of all types of radioisotope techniques; or (*b*) the development of new measuring techniques for radioactive materials and ionizing radiations and the investigation of limits of performance of detectors—The Group Recruitment Officer (1270/34), United Kingdom Atomic Energy Authority, A.E.R.E., Harwell, Berks.

Laboratory Technician (male or female, with experience in biology and interested in animals)—The Secretary, Furzedown College, Welham Road, London, S.W.17.

Lecturer in Applied Physics, to assist in establishing Higher National Certificate courses in Applied Physics—The Principal, Farnborough Technical College, Boundary Road, Farnborough, Hants.

Lecturer (man or woman, with an honours degree in physics and preferably a teaching qualification) in Physics at the Medical School, Kano, Northern Nigeria, to teach to advanced level—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/408/030.

Lecturer (preferably with an active interest in research, together with teaching and/or industrial experience) to teach Physical Chemistry to the standard of the Diploma of Technology, B.Sc. (Special) Chemistry and A.R.I.C.—The Principal, College of Technology, Queen Street South, Huddersfield.

Principal (preferably under 50, with a degree in engineering or applied science or professional equivalent, together with wide experience of technical education) of the recently established Institute of Technology, Jamaica—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.114/32/09.

Professor of Mechanical Engineering, and a Lecturer in Electrical Engineering (Electrical Power) at the University of Ceylon—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting E.9/TCS/216-7CEY.

Scientific Officer (honours graduate, preferably in biochemistry or physiology), to work, both in laboratory and with experimental animals, on nutritional problems in pigs—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 59/1.

Technician (preferably with previous experience) for the Chemistry Laboratories—The Secretary, Royal Holloway College (University of London), Englefield Green, Surrey.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Scientific Council for Africa South of the Sahara. Publication No. 32: Ninth Meeting of the Scientific Council, Accra, 1958. Pp. 173. (Published under the sponsorship of the Commission for Technical Cooperation in Africa South of the Sahara.) (London: Secretariat, C.C.T.A./C.S.A., 1958.) [1011

Building Research Station Digest, No. 115 (October 1958): Ready-Mixed Concrete. Simplified Daylight Tables. Pp. 4. (London: H.M. Stationery Office, 1958.) 3*d*. [1011

Bulletin of the British Museum (Natural History). Entomology. Vol. 7, No. 5: Revision du Genre *Exocentrus* Mulsant (Col., Cerambycidae). Par S. Breuning. Pp. 209–328. 40*s*. Vol. 7, No. 6: New and Little Known Emesinae (Reduviidae, Hemiptera) in the British Museum (Natural History), London. By P. Wygodzinsky. Pp. 329–346. 6*s*. Vol. 7, No. 7: New Species and Subspecies of Odonata, and On Some Trichoptera from S. Rhodesia and Portuguese East Africa. By D. E. Kimmins. Pp. 347–368. 7*s*. (London: British Museum (Natural History), 1958.) [1011

Department of Scientific and Industrial Research: Road Research Laboratory. Road Research Technical Paper No. 42: Reflex Reflectors. By Dr. K. N. Chandler and J. A. Reid. Pp. iv+30+4 plates. (London: H.M. Stationery Office, 1958.) 2*s*. 6*d*. net. [1011

British Standards Institution. British Standard for Anatomical, Physiological and Anthropometric Principles in the Design of Office Chairs and Tables. By Dr. W. F. Floyd and Dr. D. F. Roberts. Pp. 20. (B.S. 3044: 1958.) (London: British Standards Institution, 1958.) 5*s*. net. [1011

British Electrical and Allied Industries Research Association. Technical Report L/T 360: The Polymerization of Organic Compounds by Ionizing Radiation. By C. E. King. Pp. 7+4 figures. 7*s*. 6*d*. Technical Report L/T 364: The Effects of Small Discharges on Some Insulating Materials. 2: At Atmospheric and Reduced Pressures. By N. Parkman. Pp. 19+16 figures. 18*s*. (Leatherhead: British Electrical and Allied Industries Research Association, 1958.) [1011

Death Rates by Age and Sex for Tuberculosis and Selected Respiratory Diseases, England and Wales, 1911–1955. By R. A. M. Case and Joyce L. Harley. Pp. ix+20. (London: Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospit 1958.) [10

Philosophical Transactions of the Royal Society of London. Ser A: Mathematical and Physical Sciences. No. 989, Vol. 251 (6 Novem 1958): An Experimental Determination of the Fermi Surface Lead. By A. V. Gold. Pp. 85–112+plate 1. 10*s*. 6*d*. No. 990, Vol. 2 (6 November 1958): The Polarization of Atomic Line Radiati Excited by Electron Impact. By I. C. Percival and M. J. Seat Pp. 113–138. 8*s*. (London: Royal Society, 1958.) [10

Other Countries

State of California: Department of Fish and Game. Fish Bullet No. 106: Age and Length Composition, Pacific Coast Catches, Sardi and Pacific Mackerel 1955–56 and 1956–57 Seasons; and the Northe Anchovy, 1954–55 through 1956–57 Seasons. Pp. 72. (Termin Island, Calif.: Department of Fish and Game, 1958.) [10

Proceedings of the United States National Museum. Vol. 10 No. 3400: A Revision of the Eels of the Genus *Conger* with Descriptio of Four New Species. By Robert H. Kanazawa. Pp. 219–267+ plates. Vol. 108, No. 3401: Three North American Cretaceous Fish By David H. Dunkle. Pp. 269–277+3 plates. Vol. 108, No. 340 Taxonomy and Nomenclature of Three Species of Lonchura (Ave Estrildinae). By Kenneth C. Parkes. Pp. 279–293. Vol. 108, No. 340 Advances in Our Knowledge of the Honey-Guides. By Herbert Frie mann. Pp. 309–320. (Washington, D.C.: Government Printi Office, 1958.) [10

United States Department of Commerce: Coast and Geodetic Surve Technical Bulletin No. 3 (May, 1958): Recent Increases in Coast Water Temperature and Sea Level—California to Alaska. By H. Stewart, Jr., B. D. Zetler and C. B. Taylor. Pp. 11. (Washingto D.C.: Government Printing Office, 1958.) 20 cents. [10

Tobacco Research Board of Rhodesia and Nyasaland. Bullet No. 7: Barn Construction and Curing Procedure. Pp. 16+9 drawin (Salisbury: Tobacco Research Board of Rhodesia and Nyasalan 1958.) [10

Annals of the New York Academy of Sciences. Vol. 72, Article Lymphocytes and Plasmacytes in Nucleoprotein Metabolism. Margaret A. Kelsall and Edward D. Crabb. Pp. 293–338. Vol. 7 Article 10: Quantum Aspects of Catalysis: Oxidations and Oth Reactions of Ethylene. By Raymond R. Myers. Pp. 339–352. (Ne York: New York Academy of Sciences, 1958.) [10

Northern Rhodesia: Geological Survey Department. Report No. The Geology of the Kariba Area. By Dr. Brian Hitchon. Pp. vi+41+ plates+4 maps. (Lusaka: Government Printer, 1958.) 30*s*. [10

Canada: Department of Northern Affairs and National Resourc National Museum of Canada. Bulletin No. 151: Roundelays. Fo Dances and Games collected in Canada and New England, and pr pared by Marius Barbeau. Piano arrangements by Maurice Blackbur Interpreted in English by Joy Tranter. Illustrations by Marjo Border. Cover by Grave Welvin. Pp. 104. 2.50 dollars. Bulletin N 155: A Zoogeographical Study of the Amphibians and Reptiles Eastern Canada. By J. Sherman Bleakney. Pp. iii+119 (49 map 2 dollars. (Ottawa: Queen's Printer, 1958.) [10

Archives de l'Institut de Paleontologie Humaine, Paris. Mémoi 29: La Grottée de Fontéchevade. Deuxième partie: Anthropolog Par Henri-V. Vallois. Troisième partie: Géologie et Paléontolog Par H. Alimen, C. Arambourg et A. Schreuder, avec la collaboration G. Henri-Martin, J. Berlioz et J. Bouchud. Pp. 262+6 planch (Paris: Masson et Cie., 1958.) [10

Smithsonian Institution. List of Smithsonian Publications Availa for Distribution, June 30, 1958. Compiled by Eileen M. McCarth Pp. vi+54. (Publication 4344.) (Washington, D.C.: Smithsoni Institution, 1958.) [11

Annual Report of the Board of Regents of the Smithsonian In tution Showing the Operations, Expenditures, and Condition of Institution for the year ended June 30, 1957. Pp. x+499+74 plat (Publication 4314.) (Washington, D.C.: Government Printing Offic 1958.) 4.50 dollars. [11

Chicago Natural History Museum. Fieldiana: Zoology. Vol. No. 6: Notes on African Bulbuls, Family Pycnonotidae—Class Av By Austin L. Rand. Pp. ii+145–220. (Chicago, Ill.: Chicago Natu History Museum, 1958.) 1.25 dollars. [11

Annals of the New York Academy of Sciences. Vol. 73, Article Third Tissue Homotransplantation Conference. By John Marq Converse, Blair O. Rogers and 75 other authors. Pp. 539–868. Vol. Article 1: Enzymes in Blood. By L. P. White and 81 other autho Pp. 1–384. (New York: New York Academy of Sciences, 1958.) [11

Department of Scientific and Industrial Research, New Zeala Information Series, No. 16: The Rabbit Problem in New Zeala By Walter E. Howard. Pp. 47. (Wellington: Government Print 1958.) 4*s*. [12

Annales de l'Institut de Physique du Globe de l'Université Paris et du Bureau Central de Magnétisme Terrestre, Tome 29. P 170. (Paris: Université de Paris, 1958.) [12

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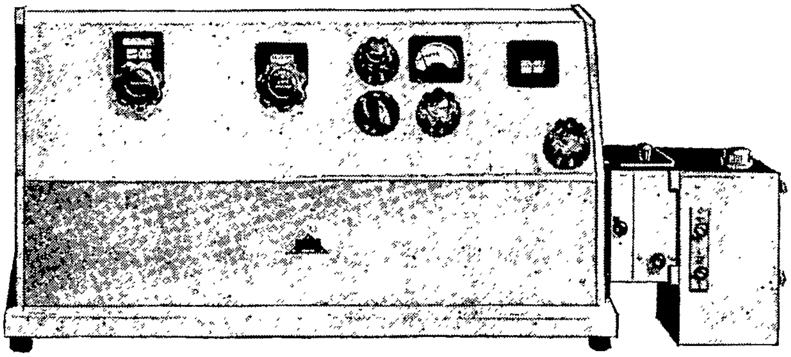

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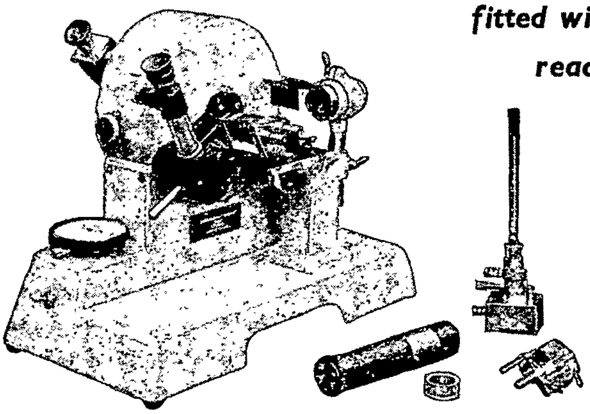

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NATURE CONSERVATION AND ECOLOGICAL RESEARCH

IN a country so thickly populated as Britain, the sequestration of land for purposes other than those of immediate economic or social advantage inevitably presents serious problems, of which the expenditure of public money on the project is but one. In response, however, to the recommendations of the reports of the Wild Life Conservation Committees which were published in 1947[1,2] there was established the Nature Conservancy, with the express intention that it should acquire and maintain land where it is regarded as necessary for the conservation of the flora and fauna, direct research on the ecology of the wild life of Britain and act as a clearing house for advice and information in relation to any problems which may arise in this ecological field, whether within its reserves or elsewhere in the country. It being recognized that such a service is primarily dependent upon long-term research, the wise decision was made that the Conservancy, like the Agricultural Research Council, the Department of Scientific and Industrial Research and similar bodies, should be responsible to Parliament, not through any departmental head, but direct through the Privy Council and its Lord President.

Despite having had barely ten years of functional existence, the Nature Conservancy has pursued a vigorous policy of implementing the major recommendations of the Wild Life Conservation Committees, which were embodied in the terms of reference under which the Conservancy was established. Thus, it now possesses or controls some 125,000 acres of land as National Nature Reserves, and may be regarded as approximately half-way towards attaining a final target comprising some 140 areas of land of the most diverse ecological interest. In addition, two field research stations, Merlewood at Grange-over-Sands and Furzebrook near Wareham, have been equipped; smaller provision of laboratories and equipment has been made at some of the reserves; while a system of regional officers exercises an all too slender integration of interests between the Conservancy and land-owners and land-users throughout the country.

The Select Committee on Estimates has recently[3] subjected the affairs of this youngest of our scientific services to scrutiny and has expressed its satisfaction with the potential value to the country of its work. To the scientific ear there is an oddly parochial ring to the qualification: "It is important that wisdom and common sense are brought to bear in selecting projects for research which will redound to the prestige and prosperity of the nation". But we may rest assured that so small an objective will be achieved within the framework of the Conservancy's policy of enlarging our knowledge of the ecology of the British Isles, and it is a matter for satisfaction to biologists that this framework has received approval. The Select Committee's sympathetic appreciation contains four major reservations. Of these, two relate to the administrative organization of the Conservancy and can be left for adjustment to the domestic wisdom of those immediately concerned. The other two, however, relate to scientific policy and call for some comment.

It is a matter of concern to the Select Committee that on one hand the Conservancy is committed to a policy of increasing substantially, and as rapidly as possible, its holding of nature reserves, while on the other the provisions for staffing and maintaining some of those already acquired are very thinly spread. The Committee accepts that it is vital to complete as early as possible the programme of dedication of National Nature Reserves, if only to secure that too much is not lost to the demands for development which are being actively pressed by many interests. But it foresees, with some alarm, that management of the new reserves, even in a manner comparable only with that of existing areas, must result in the presentation of bills for equipment, maintenance and staff which must swell the Conservancy's annual budget by considerable sums. Moreover, the visiting sub-committee which inspected Moor House Reserve in Westmorland was clearly appalled by the difficulties and hardships suffered by workers there, with no telephonic communication and only a badly surfaced seven miles of moorland track and a 'Land Rover' as their link with civilization. It may be commented in passing that such conditions, while clearly difficult for the administrator and the lay worker, may be regarded as almost normal by the field biologist, and indeed such remote isolation is eagerly sought by them for the freedom from interference and interruption by the public which they offer.

The solution to the problem offered by the report of the Select Committee is the recommendation that existing reserves be given prior claim on finance both for maintenance and for research, except where it appears that a newly acquired reserve may be liable to deteriorate in scientific value unless it is adequately staffed and managed. This same problem of provision of, in particular, scientific staff is evidently in mind in the subsequent suggestion, that greater efforts be made to induce the universities to play a larger part in the ecological investigations of the Conservancy. It is not, of course, within the terms of reference of the Select Committee to recommend expenditure beyond the estimates which are under consideration. It is, however, difficult to escape the conclusion that this may become necessary if the Conservancy is to play its proper part. At present we spend annually something of the order of twopence a head of population on its work, and this figure will rise to nearly threepence by the time the programme of acquisition of reserves had been completed. This by any standard cannot be described as extravagant, and contrasted with expenditure on parallel projects in the United States and elsewhere it is conservative. Moreover, by virtue of our situation on the seaboard of Europe and, above all, of the extreme geological diversity to be found within so small a compass within the British Isles, it is probably true that ecological conditions present a far broader variety here than is to be found in close proximity almost anywhere else in the world. It follows that, to achieve its primary object of understanding the ecology of Britain, the Nature Conservancy must be able to prosecute at one and the same time active research in a number of different reserves. It is true that attainment of such an objective is far distant, and inevitably priorities must be determined. It is also true, however, that the pace and intensity of human interference with natural conditions have increased out of all measure during the past fifty years, and is still increasing. It is therefore most urgent that we should endeavour to obtain at least an inkling of the effects of our activities upon the world around us, and for this we need a yardstick in the form of some documentation of the conditions in those areas which have suffered least interference by man, and still remain to us. A substantial increase in the annual budget of the Nature Conservancy may well, therefore, prove a long-term economy in saving us from the ecological mistakes the cost of which in the past may be readily appreciated from a perusal of Mr. C. S. Elton's latest book[4].

A strengthening of the link between the Conservancy and the universities will undoubtedly be welcomed by both parties. There are, however, difficulties which must be faced. In most universities the disciplines cognate to ecological research tend to be departmentally isolated, and the workers themselves are for the most part unused to the discipline of team-work such as is demanded by most of the Conservancy's major projects. In addition, too, many senior workers are caged by administrative and teaching duties to such an extent that they are rarely free to undertake full ecological investigations, most of which demand freedom to attend to them in the field throughout the year. This handicap becomes particularly forceful where the region of study is, as are most of the National Nature Reserves, remote from the individual's laboratory. It follows that the conscientious university teacher must, if he is interested in ecology, do a great deal of his work by proxy, building up a school of young research workers under his inspiration and guidance. This immediately brings back the problem of finance. Now the Nature Conservancy at present spends about 10 per cent of its annual budget, namely, some £30,000, in subventions for ecological research by university and other workers outside its immediate orbit. This, in 1957, enabled the Conservancy to support sixteen senior university workers and some thirty postgraduate students ; but owing to financial stringency it was impossible to consider making any new grants during the year despite requests in relation to a number of important projects. It seems, therefore unrealistic to expect increased co-operation from universities, the resources of which are already overstrained, in the absence of any means of providing the financial support this demands.

It is necessary to join issue with the Select Committee over its recommendation 19 on the subject of revenue. This postulates that the Conservancy should make greater efforts to obtain revenue from its reserves and, by implication, should instruct its regional officers to give time and thought to devising means of deriving some income from the reserves in their charge. It cannot be too strongly emphasized that the functions of the Nature Conservancy are those of research, conservation and advice ; its regional officers provide the main lines of liaison in relation to these services, while the reserves are its laboratories. These officers are few in numbers and each is already fully occupied with a large area in which to exercise a variety of delicately adjusted functions. None is by training as equipped to deal with the commercial transactions envisaged as is the land agent, and it would severely handicap them in the performance of their scientific duties were they called upon to look for revenue from their reserves.

On the larger issue, that the Conservancy should be expected to seek to derive profit from its lands ; first, it must be realized that most of the land on which reserves are situated is very poor, this being one of the major reasons underlying its selection. But apart from this, it is not the function of research laboratories to make money out of side activities, and it would seriously handicap the progress of original investigations should such a duty be imposed upon them. This is not to suggest that where a market exists for the end-products of the normal research and maintenance activities carried on, this should not be exploited. Indeed, the officers of the Conservancy have produced evidence that a small revenue is derived from sales of timber and the like and from grazing. This must, however, be allowed to remain incidental to the scientific management if the reserves are to be efficiently maintained. It is frequently necessary to extinguish sporting rights and to modify the management of land in order that a natural—or more natural—balance may establish itself for the purposes of the scientific investigations, the results of which will provide ultimately a true profitable return in an increased knowledge of the causes which underlie natural processes and the results of our maltreatment of them.

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[1] Conservation of Nature in England and Wales. (Cmd. 7122.) Pp. v+139. (H.M. Stationery Office, London, 1947.) 4*s.* net.

[2] National Parks and the Conservation of Nature in Scotland. (Cmd. 7235.) Pp. iv+72. (H.M. Stationery Office, London, 1947.) 2*s.* net.

[3] Seventh Report from the Select Committee on Estimates together with the Minutes of the Further Evidence taken before Sub-Committee *C* and an Appendix. Session 1957–58. Nature Conservancy. Pp. ix+79. (H.M. Stationery Office, London, 1958.) 5*s.* net.

[4] Elton, C. S., "The Ecology of Invasions by Animals and Plants" (Methuen and Co., Ltd., London, 1958).

CHARACTERISTICS OF THE BARTONELLAS

Morphologische, Biologische und Serologische Eigenschaften der Bartonellen

Von Dr. Reinhard Wigand. Pp. viii + 71. (Stuttgart: Georg Thieme Verlag, 1958.) 7.80 D.M.

THIS book is not a monograph on bartonellas, which, by the way, would be most welcome. It gives a detailed record of the author's own work on the subjects mentioned in the title.

Electron microscopical studies have mainly confirmed early observations. They have, however, made possible precise measurements of the various members of the group. (The reader should note a printing error: the flagella of *Bartonella bacilliformis* are not 20μ thick as stated on p. 23.) The cytochemical studies have shown that both *Haemobartonella muris* and *Eperythrozoon coccoides* contain ribonucleic and deoxyribonucleic acids. The conclusion concerning the structure of their outer layer is somewhat obscured by the fact that Wigand uses the term membrane loosely, and not in the modern sense, as opposed to bacterial wall. The study of the action of antibiotics is reported in detail and the tables giving the comparative sensitivity of various bartonellas to antibiotics are certainly useful. So far as infection with *H. muris* is concerned, the statement that a complete picture of infection is observed only in splenectomized mice is not valid. The work of Gledhill and Andrewes concerning the co-operative action of *Eperythrozoon* and of the virus of hepatitis could perhaps have been quoted in the discussion of the pathogenic activity of *Eperythrozoon*.

The demonstration by Wigand of a serological relationship between *H. muris* and *Eperythrozoon* is important. It was predictable since a typical *Eperythrozoon* phase has been recognized in *Haemobartonella canis* (which should have been mentioned in the book). This poses the problem of the 'round' form of *Bartonella bacilliformis* observed by Noguchi and which is interpreted by Wigand as the result of a degeneration. The bodies observed by Noguchi, however, are indistinguishable from typical *Eperythrozoon* and are not to be confused with the coccoid forms of involution so easily observed in bartonellas, or in any other bacteria. It is clear that if an *Eperythrozoon* phase exists in the life-cycle of the human *Bartonella*, the problem of its affinities would have to be reconsidered.

Wigand has not been able to detect serological relationships between *Eperythrozoon* of the mouse and *Anaplasma* of the bovines. It seems perfectly justifiable, however, to conclude, with Wigand, as was already done in 1931 by Lwoff and Vaucel, that the two organisms are related.

According to Wigand, *Bartonella* is a bacterium. *Haemobartonella*, however, is supposed to lack any of the typical features of bacteria. It is neither a virus nor a protozoon. For Wigand, they resemble the pleuropneumonia group of organisms. But these, being bacteria, certainly possess some features of the Schizomycetes group. If *Haemobartonella* and *Eperythrozoon* are pleuropneumonial-like organisms they should also possess bacterial characteristics. Otherwise, they would belong nowhere. Finally, the reader is puzzled by Wigand's statement that *Hæmobartonella* and *Eperythrozoon* are devoid of a membrane, of an internal structure and of cellular organization (p. 26). How these strange creatures, which, by the way, are extracellular parasites, manage to grow, to multiply true to type and to survive, is a mystery. The very existence of *Haemobartonella* and *Eperythrozoon* would, in my opinion, make it probable that, like all other organisms, they do have a cellular organization.

Despite the absence of index, the specialists on *Bartonella* and *Haemobartonella* will find in this book a number of useful technical, electron-microscopical, chemotherapeutical and serological data.

A. LWOFF

COLORIMETRY IN BIOCHEMISTRY

Colorimetric Analysis

By Noel L. Allport and Dr. J. W. Keyser. Vol. 1: Determinations of Clinical and Biochemical Significance. Second edition. Pp. xi + 424. (London: Chapman and Hall, Ltd., 1957.) 50*s*. net.

COLORIMETRIC analyses, using photoelectric apparatus to measure the intensity of transmitted light, are nearly always superior to gravimetric or titrimetric methods in speed of assay and in the avoidance of the exercise of personal judgment in making the final readings. Moreover, the cleaning and maintenance of apparatus are usually simpler in the case of colorimetric methods. It is not surprising, therefore, that in clinical biochemical work colorimetric methods are often the methods of choice; their slight inferiority in accuracy, in some cases, being offset by their suitability for the performance of large numbers of routine assays.

In the volume under review Mr. N. L. Allport and Dr. J. W. Keyser have given us a collection of about one hundred colorimetric techniques, covering a much wider range than that usually needed in clinical work. This volume is an extension and revision of section three of the first edition, published in 1945, which dealt with analyses of clinical and biochemical significance. The number of analyses described has been increased about threefold. Among the additions specially likely to interest the clinical chemist, assays of adrenocortical steroids, bromsulphthalein, congo red, dextran, dinitro-orthocresol, Evans blue, inulin, protein-bound iodine, acid optimum phosphatase activity and urobilinogen should be noted.

As in the first edition, description and discussion of colour-measuring apparatus have not been included. The critical selection of material, valuable discussion of each method, and clarity of presentation which were striking features of the first edition have been fully retained.

The wide range of analyses covered adds greatly to the general interest of the book. The clinical chemist should find here many suggestions for additions to his established routine and for techniques which show improvements on the older methods.

Colorimetric methods cannot always be the methods of choice. This is recognized and indicated where necessary, as, for example, in the description of the assay of calcium in serum, where the well-established and straightforward titration of the precipitated calcium oxalate receives due recognition.

In the section dealing with the assay of carbon monoxide in blood, a good feature is the inclusion of the old, but simple and reliable, tannic acid technique. However, the titrimetric technique using the Conway micro-diffusion unit, and based upon the liberation of hydrochloric acid from palladium chloride by carbon monoxide, would probably be the method of choice in most clinical laboratories.

One wishes that the important question of the assay of adrenaline and noradrenaline in urine could have been discussed in the section on adrenaline assay. In recent years clinicians have shown a keen and very understandable interest in this assay, because it is a valuable diagnostic aid for investigating patients suspected of harbouring a phaeochromocytoma. While assay by the cat blood pressure technique is probably the method of choice, many laboratories have no facilities for this procedure. Colorimetric methods have been described, but only techniques involving measurement of fluorescence in ultra-violet light seem at present to be adequate.

In the section dealing with the assay of uric acid in blood no mention is made of the simple procedure of Benedict and Behre for removing the interfering substance thioneine from blood filtrates. Doubtless the authors consider this refinement unnecessary for both the methods they quote, but it should be borne in mind by all concerned with this assay.

An appendix to this book gives, with references, a list of thirty-two further methods, not included in the text. A short description of the principle underlying each of these methods is included. Finally, full indexes of authors and subjects conclude a practical and interesting volume which should certainly find a place in the laboratories of all who use colorimetric methods in clinical or biochemical work.

N. R. LAWRIE

AFRICAN APHIDS

A Study of the Aphididae (Homoptera) of East Africa

By V. F. Eastop. (Colonial Research Publications.) Pp. vi+126. (London: H.M. Stationery Office, 1958.) 27*s*. 6*d*. net.

It is surprising that so little attention has been paid to surveys of the aphid fauna in the tropical and subtropical countries of the world in view of the economic importance of this class of insect. This is particularly true of Africa south of the Sahara, where the fauna has never been systematically studied and where, in consequence, many of the names that have been in common use in East Africa have now been found to be wrong. Yet it is of vital importance to the economic entomologist that he should know accurately the identity of the species with which he has to deal if he is to be able to benefit from the experience of others and from what has been recorded about it. Furthermore, in recent years, the Aphididae, as proved vectors of plant diseases, have assumed an even greater economic importance.

The objects of the present work, according to the author, are to provide a means of identifying those aphids known to occur in East Africa, to make possible the identification of those species occurring in adjacent territories that are not known from East Africa at present, and finally to bring together under each species the biological data available.

The foregoing objects have been admirably achieved. The number of known species from the region has been increased from 30 to 80, any one of which can be run down by following the keys which take one through each category of the classification down to species. Mistaken identities of some species are rectified and other species are synonymized. A new species and a new subspecies are described and recognition characters are given in the case of most species. The figures are adequate but their arrangement and that of the legends might have been improved. A list of host plants arranged alphabetically in families and of genera within families will be most helpful in providing an indication of the possible identity of an aphid species and will form the basis of a much more extended list as more knowledge is accumulated. The book is indexed and a comprehensive list of references is supplied.

This is the type of taxonomic work that is so valuable, and becoming increasingly more so, to the economic entomologist. It is the first survey of its kind made in East Africa south of the Sahara, and it should enable entomologists and agricultural officers to recognize their species accurately.

The Colonial Office is to be congratulated on promoting this study, and it is to be hoped that it will be followed by similar surveys in other areas of Africa and elsewhere. If they are all as well and carefully executed as in the present instance they will mark an important advance.

W. J. HALL

PSYCHIATRY IN WARTIME

Psychiatry in the British Army in the Second World War

By Robert H. Ahrenfeldt. Pp. xv+312. (London: Routledge and Kegan Paul, Ltd., 1958.) 35*s*. net.

DR. AHRENFELDT fights once again the battles fought during the Second World War by British Army psychiatrists, "unwelcomed and regarded with suspicion, if not despised, . . . to overcome prejudices, administrative resistance and executive inertia, while simultaneously caring for their patients . . . " (p. 251). The brave partisan attitudes so frankly displayed in this passage pervade his book. They are not compatible with a discerning appraisal of the scientific, technical or administrative problems. Yet account should be taken of them by everyone who studies the history of Army psychiatry, or, for that matter, the development of civilian psychiatry in the years immediately following the War, because they appear to have been shared in some degree by several of his colleagues. Whether or not Dr. Ahrenfeldt wins the reader's sympathy, his book serves a useful purpose as a concise and accurate chronicle of the changes in official policies during the War years.

Let no one diminish the achievements of Army psychiatrists. A great deal was demanded of them. Equipped with the knowledge and skills acquired during their medical training and their specialist experience in hospitals and private consulting rooms, they were required to tackle not only the problems of organizing the treatment and disposal of psychiatric casualties, but also the multifarious problems of personnel and officer selection, training, discipline and morale and the management in Army units of the dull, unstable and delinquent. They had to be experts in matters lying outside their previous experience because there were no other experts. Many of the problems had been recognized in the First World War, and were noted in the report of the Southborough Committee in 1922, but the Army entered the Second

World War without any organization or trained staff to meet them. The Royal Navy and the Royal Air Force were perhaps more successful than was the Army in utilizing the services of civilians trained in the methods of social and applied psychology, and the psychiatrists in these Services dispersed their efforts less widely.

Many of the criticisms to which Dr. Ahrenfeldt makes reply appear to have arisen when the expertness of psychiatrists was called in question. For example, their participation in the selection of officers at War Office Selection Boards was controversial. A special position was claimed for the psychiatrist "as the only member of the Board with adequate scientific training and experience in the assessment of personality" (p. 66). Yet it could reasonably be doubted whether he was therewith fitted for the position claimed for him. The problems were new ones, and the immodest insistence by some psychiatrists of the superiority of their theories and techniques, in this and other matters, did damage to their reputation. However, in assessing the rights and wrongs of their claims, it should be remembered that the problems were important and urgent.

D. Russell Davis

PHONETICS

Manual of Phonetics

Edited by L. Kaiser. Pp. xv+460. (Amsterdam: North-Holland Publishing Company, 1957.) 38 guilders.

THIS book is divided into six parts, dealing respectively with the history of phonetics, the basal sciences of phonetics, phonetic research, phonetics in its relation to linguistics, phonetics in its relation to other sciences, and phonetics and the origin of speech. The twenty-eight chapters which make up these six parts have been contributed by thirty different authors (there are several collaborations), coming from fourteen different countries; they all write in English, sometimes in an English that is not very easy to follow. Curiously enough there is no contributor from Britain. The editor's introduction explains that the book is not addressed to a specialist audience, but is intended to provide a general introduction to the subject for such people as engineers, linguists, surgeons, psychologists, teachers, artists, and so on; and it is claimed that an all but complete survey of the field is provided. This, indeed, is what one would expect from a book entitled a 'manual'.

However, it is a disappointing compilation. It is certainly not a 'manual', in any sense, but is rather a collection of essays which have little unifying force behind them, and which are, moreover, of very varying worth. It does not provide anything like a complete survey of phonetics. The fundamentals of the subject are almost entirely missing: there is no detailed, systematic treatment anywhere of the basic categories of phonetic description, though such a treatment is needed for understanding many of the contributions; and there is no account of phonetic notation, apart from a few brief (and inaccurate) notes, at the beginning of the book, on the symbols used by the contributors (some of whom deviate unexpectedly from accepted practice). The languages taken into consideration fall very far short of being representative of the general range of human phonetic performance. It is disconcerting that some of the contributors do not appear to be phoneticians at all; one wonders what the collaborators who are phoneticians think of certain of the statements with which their contributions find themselves in company (such as one to the effect that "the average baby, under two months of age, is endowed with 7½ phonemes"). Several important techniques of phonetic research, including palatography and kymography, are referred to but nowhere explained. No mention is made of the uses of recording in phonetic investigation, and there is no discussion of methods of teaching pronunciation.

It is almost inevitable, in a work planned as this one appears to have been, that there should be no general body of theory common to all the contributors; it is scarcely surprising, therefore, that they contradict each other at times. More effort could have been made, however, to unify terminology: we find the same term used in two, and sometimes three, different senses by different writers (vocalization, accent, implosion, for example). What is more serious is that some terms are not explained anywhere in the book (for example, mixed vowel, lenis, fortis). A glossary of technical terms should have been provided. Even a carefully prepared index would have been a help; the present one is quite inadequate.

There are outstanding contributions by Peterson, Martinet, and Jakobson and Halle; but it is nevertheless not possible to recommend the book (quite apart from its price) to the layman who wants a manual of phonetics.

D. Abercrombie

SIR CHARLES SHERRINGTON

Sherrington

Physiologist, Philosopher and Poet. By the Rt. Hon. Lord Cohen of Birkenhead. (The Sherrington Lectures, 4.) Pp. xiv+108+3 plates. (Liverpool: Liverpool University Press, 1958.) 17*s.* 6*d.*

THIS volume is the fourth of the series of Sherrington Lectures instituted by the University of Liverpool in recognition of the distinguished contributions of the late Sir Charles Scott Sherrington to physiology and medicine, and of his association with the University as its George Holt professor of physiology during 1895–1913.

Lord Cohen has been the University's professor of medicine for a generation, and has chosen for his theme a much more personal subject than have the previous lecturers. He has also given reproductions of the Augustus John painting which hangs in the University Club of Liverpool, and of that by R. G. Eves which is in the Royal Society of London, as also of the photograph by Allan Chappelow which was chosen by Sherrington as the frontispiece to the second edition of "Man on his Nature", which was published on Sir Charles's ninety-fourth birthday. Apart from these three plates and a number of text figures, the book contains in its 108 pages a brief introduction, Lecture 1 which is biographical, Lecture 2 which deals with Sherrington as physiologist, and Lecture 3 which is of him as philosopher and poet. To these are added a bibliography, based on writings compiled for Denny-Brown's edition of "Selected Writings" and on John Fulton's obituary notice in the *Journal of Neurophysiology*.

Not so long ago it was a considerable labour and effort to piece together Sherrington's biography, but thanks to Prof. E. G. T. Liddell ("Obituary Notices of Fellows of the Royal Society", **8**, 241; 1952), Lord Adrian (*Proc. Roy. Soc. Med.*, **50**, 991; 1957), and others the effort has long since become less exacting, and opportunities for originality in Lord Cohen's Lecture 1 correspondingly less. One should, however, add the Beaumont Lecture given at Yale University on November 15, 1957, by "Sherrie's" son, Mr. C. E. R. Sherrington, for it is a noteworthy complement to other sources and is not too widely known.

Of his Lecture 2 Lord Cohen modestly wrote, "I have been able to touch only briefly and superficially on Sherrington's contributions to physiology. The work of a genius, who for half a century laboured with undiminished zest to unravel some of Nature's secrets, cannot be compressed, even in its essentials, into one lecture. It may well be that others would have chosen different examples from his work and a different emphasis to convey their assessment of his contribution to neurophysiology". Lord Cohen also refers to Sherrington's influence on the development of clinical neurology, where not only did he add, "as no-one had previously done, to the facts but above all he provided the concepts which made them hang together".

Lecture 3 is the most difficult to review, for it passes from physiology to the age-old problem of life and mind, posing difficulties at which Sir Charles did not baulk but which he recognized rather than solved. Then it completes the writer's would-be scope by referring to Sherrington's poetry and poetic thought, which make up a very interesting part of the full story, but need a poetic atmosphere for their proper discussion.

This review cannot give that, but perhaps enough has been said to reveal the scope of the lectures, and to whet the would-be reader's appetite for more. One cannot be too much in thought with Sherrington, or be too thankful that so wonderful a person lived in our time. We are in debt to Lord Cohen for his delightful tribute to so outstanding a member of the Liverpool faculty of an earlier day.

K. J. Franklin

MISSILE ENGINEERING DESIGN

Missile Engineering Handbook

By C. W. Besserer. (Principles of Guided Missile Design, Vol. 4.) Pp. xi+600. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 109*s*.

Guided Missiles

Operations, Design and Theory. (Sponsored by the Department of the Air Force.) Pp. vi+575. (New York: McGraw-Hill Book Company, Inc.; London: McGraw-Hill Publishing Company, Ltd., 1958.) 62*s*.

The ever-increasing development of guided weapons for military purposes, research rockets for upper atmosphere measurements, and earth satellites and space probes implies a huge host of scientists, technicians and engineers working in the many disciplines of science and technology involved in these new devices. Despite the growing need for authoritative text-books on the associated wide range of applied science, it has, until recently, been difficult to find more than semi-popular expositions, liberally strewn with illustrations of war-time German missiles and American missiles at the instant of launch. The American series of admirably produced volumes on "Principles of Guided Missile Design", edited by a retired U.S. Navy captain for many years closely associated with missile development, and published by Van Nostrand, has gone far to rectify the situation.

This series began in 1955 and the fourth volume—"Missile Engineering Handbook"—is intended as a compendium of design data for use by engineers and technicians who may be assumed to have acquired a good knowledge of basic principles from the earlier volumes. It contains 400 pages of closely packed tables, graphs, nomograms and charts providing a remarkable accumulation of engineering data in the various subjects which make up the complex applied science of missile design. One may browse through specific gravity tables with such curious items as porphyry, hemlock or pine-yellow long-leaf, and speculate on their usefulness in the mundane business of fabricating anti-aircraft rockets, or pause to check the cumulative probability of meteor hits on journeys through space. In the intervals, however, can be found exhaustive tables of properties of materials, rocket propellant performance, the Earth's principal characteristics and gravitational field out to great heights and many other topics, together with most of the basic formulæ useful for design calculations. Much information is given of great value for preliminary design studies, divided into chapters on properties of the atmosphere, materials, aerodynamics, propulsion, avionics and space flight. The data on materials and structural design are particularly extensive. However, the sections on specifications for environmental tests and ground equipment and what seemed to be reminder lists for the process of detail design, all based on American practice, are of limited interest. The chapters on aerodynamics and avionics are rather brief. At the end is a 160-page glossary of terms commonly used in missile engineering, which should prove most valuable to newcomers in the subject. The layout and printing are extremely clear. There are, however, quite a number of misprints and some errors in basic constants, for example, the powers of π on p. 23 are completely inaccurate. These errors raise some doubts regarding the accuracy of the multitude of quantitative facts throughout the book, which only detailed and intensive study could check.

By contrast the second book, "Guided Missiles—Operations Design and Theory" deals almost entirely with elementary principles. It is based on a military training manual written some three years ago at the U.S. Air Force Missile School in Colorado and is obviously intended for general instruction of military personnel. Although at times unsound on basic principles, for example, force, momentum and weight are sadly confused in stating Newton's laws, the book gives a very understandable account of the main design principles and features of typical missile guidance and control components. The sections on systems are less successful, and there are noticeable gaps in the treatment of servo-mechanisms and closed-loop systems. The text is profusely illustrated throughout by exceptionally clear line and half-tone diagrams. The subject-matter should be easily grasped by a reader with mathematics and science to Intermediate B.Sc. standard and, despite a tendency towards diffuseness and occasional inaccuracy, forms a good introduction to all aspects of missile development.

Basic Automatic Control Theory

By Prof. Gordon J. Murphy. (The Van Nostrand Series in Electronics and Communications.) Pp. xi+557. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1957.) 9 dollars; 67*s.* 6*d.*

THIS book gives a detailed treatment for most of the basic theory pertinent to the analysis of linear feed-back control systems. The author deals first with Routh's criterion for stability, and with calculation of ultimate-state response. Techniques used in frequency response and time-response calculations are described. These include the *G*-plane (Nyquist) polar plot, the use of Bode gain-frequency diagrams, the root locus method for obtaining closed loop poles of the characteristic equation of a system from its open-loop poles, and the construction of the system time response from the closed-loop poles. Floyd's method for constructing impulse response from frequency response is also shown.

The introductory chapters, illustrated by a large number of very clear schematic and block diagrams, present various examples of control system components, and introduce the concept of transfer functions for each component part of a system. Block diagrams are built up for typical systems, and these are reduced to simple signal-flow diagrams. Laplace transform theory is also included among the introductory chapters, and the final chapter in the book gives a brief account of analogue computors and their use in simulation of feedback control systems. Certain parts of linear theory have been omitted, including the behaviour of linear systems with random input signals, and phase-plane analysis, but such omissions do not detract from the value of the book. Numerous worked examples are used throughout to illustrate the theory presented, and these examples are invaluable in providing a sound practical understanding of the subject. The book should prove useful to final-year and postgraduate students as well as to servo-design engineers, especially in respect to the excellent examples and unworked problems.

M. J. SOMERVILLE

Science in Schools

Proceedings of a Conference under the auspices of the British Association for the Advancement of Science, held on April 17th and 18th, 1958, at the Royal Geographical Society, London, S.W.7. Edited with Postscript by W. H. Perkins. Pp. viii+150. (London: Butterworths Scientific Publications, 1958.) 15*s.*

DURING April 17–18, 1958, the British Association for the Advancement of Science held a conference to focus attention on the condition of science teaching in schools. The subjects discussed included the national need, science as a component of general education, scientific education for girls, the present position of science teaching, the supply of science teachers and the role of the university and teachers' training colleges in providing them, accommodation and equipment and the part played by local education authorities in their provision. Among the speakers were Lord Heyworth, Sir Solly Zuckerman, Sir Eric James, Miss E. M. Huxstep, Dr. A. W. Barton, Dr. J. W. F. Hall, Dr. B. E. Lawrence and Lord Tedder. All the speeches and discussions have now been summarized in this book, which contains an introduction by Sir Alexander Fleck and a postscript by W. H. Perkins. The British Association and publishers are to be commended for presenting the proceedings of a nationally important conference in such attractive and readable form so quickly after the conference that the views presented are still fresh, lively and urgent.

Methods of Analytical Histology and Histo-Chemistry

By Edward Gurr. Pp. xv+327. (London: Leonard Hill (Books), Ltd., 1958.) 70*s.* net.

THIS is essentially a practical book designed for use at the laboratory bench, and, with this end in view, the techniques described have been set out very fully. The volume includes all the standard histochemical techniques, and often gives details of the several variants of any particular method. The difficult subject of protein histochemistry has been well covered; the very adequate instructions for the synthesis of some of the reagents used in, for example, the localization of sulphydryl groups by Barnett and Seligman's method are a welcome feature.

For the benefit of workers who do not have ready access to libraries, certain sections of the book are introduced by a theoretical passage which includes sufficient biochemical detail for a proper understanding of the different tests. The details of each reaction are followed by a selection of notes which point out possible sources of error, and these, together with a useful appendix containing such information as a list of buffer tables, of solubilities of various reagents and the formulæ of many dyes and staining solutions, add greatly to the value of the book, which may be readily commended to all who use histochemical methods.

S. BRADBURY

Curious Naturalists

By Dr. Niko Tinbergen. Pp. 280+54 photographs. (London: Country Life Limited, 1958.) 35*s.* net.

IN his introduction to this book, Niko Tinbergen describes it as the work of a small number of naturalists who, over a period of some twenty-five years, joined him in studying the behaviour of animals in their natural environment. He would be much too modest to say that most of the work described was initiated by him and continually inspired by his never-flagging enthusiasm. His friends throughout the world will greet his book with delight; many young naturalists will discover that the field of original investigation is still largely uncharted and awaits only the lively mind allied to a curiosity which is never stilled.

The book is cleverly written. In the opening chapter Tinbergen shows how, in the lovely country of Hulshorst in Holland, his first observations began in a somewhat diverting encounter with the digger wasp, *Philanthus*. From there the story is switched to East Greenland to the study of snow-buntings and phalaropes. Further investigation of *Philanthus* is followed by the study of the fast-flying falcon, the hobby. So the book continues with more studies of insects, birds and flowers, all serving to illumine contemporary knowledge of morphology, genetics and the mechanics of evolution.

The book is written in a narrative form which commands attention and is illustrated by superb photographs and quaint line-drawings which are always relevant to the text. "Curious Naturalists" should be much read.

THE GEOLOGICAL TIME-SCALE

By DR. K. I. MAYNE
Clarendon Laboratory, Oxford

AND

DR. R. St. J. LAMBERT and D. YORK
Department of Geology and Mineralogy, Oxford

THE sequence of geological events in many parts of the world since the pre-Cambrian has been well established by palæontological studies. The relative duration of each of the various periods into which it is customary to divide post-Cambrian time has also been estimated from a comparison of the maximum thickness of sediments laid down during each period. In order to use this relative scale as a time-scale, some geological events which are unambiguously placed in it, preferably within narrow limits, must be dated in an 'absolute' fashion. It is of course essential to make sure that one is dating the supposed event, and not some subsequent one. In this manner, Holmes[1] has proposed an absolute geological time-scale, his scale *B*, which places the Upper Cambrian at approximately 450 million years ago. Recently, we have undertaken an investigation of the ages of British igneous rocks by the argon – potassium method; and we have found discrepancies between the well-established stratigraphic assignment of our samples and the Holmes *B* time-scale. It appears that this scale is too short, and that the age of 450 m.y. given to the Upper Cambrian should be closer to 650 m.y. That the Holmes time-scale is too short has already been suggested by Ahrens[2] and by Faul[3], among others.

The 'absolute' age values on the Holmes scale are based upon seven uranium – lead ages determined by Nier[4]. Some of the specimens proved to have discordant age values, and those with ages which were concordant were of somewhat doubtful stratigraphic assignment. The discordancy had previously been thought to be the result of leakage of radon. For example, in the case of the Swedish Kolm, stratigraphically well defined in the Upper Cambrian, Nier's isotopic data for lead and uranium give age values for the ratio lead-207 to lead-206 of 800 m.y., for lead-207 to uranium-235 of 440 m.y. and lead-206 to uranium-238 of 377 m.y. Assuming loss of radon to be the primary cause of this discordance, Wickman[5] concluded that the absolute age of the Kolm is 440 m.y. It is thought that loss of radon is not significant except in the case of very young minerals[6]. Ahrens has suggested that the pattern of discordant ages found is due to loss of lead; and on this basis (with Nier's data) he has remarked that "slightly greater than 800 m.y. must be considered as a possible magnitude of the Upper Cambrian". More recently, Cobb and Kulp[7] have dated the Kolm, and although they find discordant lead-207/lead-206 ages as high as 720 m.y., they believe the true age to be no greater than 550 m.y. We are grateful to Prof. J. L. Kulp for informing us during the preparation of this communication that he now believes that his samples, and those of Nier's, may have been thermally altered by a basic sill occurring 100 m. above the Kolm. It would thus appear that so far the Swedish Kolm is open to criticism as a 'calibration point', for although its stratigraphy is well established, its age is still in doubt. On the other hand, the samarskite sample cited by Holmes, which is concordant in its age values, has an uncertain stratigraphic assignment, as indicated in Fig. 1. None of the samples used by Holmes is free of criticism on one or other of these grounds. Lead age data in many cases are not amenable to an unambiguous interpretation in order to give the true age. The argon – potassium method of dating may be able to provide more precise ages for fixing known stratigraphic horizons in the absolute time-scale; and particularly so when it is corroborated by the rubidium – strontium method.

The ages of the coarse-grained British granitic rocks have been determined by us on separated biotite (which is assumed to have complete retention of its radiogenic argon) by the argon – potassium method. An account of our analytical procedure and the detailed geological description of our samples will be published elsewhere. Argon was extracted from the mineral by heating to 1,500° C. in an induction furnace, and measured both volumetrically, and by the isotope dilution technique, using argon-36 as a tracer; there was agreement by both methods

Table 1

Sample	Stratigraphic position	Mineral	Method	Age (m.y.)	Ref.
A, Chinle Formation, Colorado Plateau	Upper Trias	Pitchblende	U–Pb	[a]200–210	14
D, Beryl Mt. Pegmatite, N.H.	[b]Upper Devonian–Carboniferous	Muscovite	A–K	324	12, 19
F, Franco–German Hercynian	Upper Dinantian or Namurian	Biotite	A–K and Sr–Rb	345	3
G, Georgia Piedmont	Permo-Carboniferous	Micas	A–K and Sr–Rb	360	13
O, Bentonite, Chattanooga Shale	Upper Devonian	Biotite	Sr–Rb	414 ± 45	15
P, Givetian of Saskatchewan	Middle Devonian	Sylvite	A–K	425	17
H, Bear River, Nova Scotia	Post-Lower Devonian	Biotite	Sr–Rb A–K	370 365	8
M, Nictaux Falls, Nova Scotia	Post-Lower Devonian	Biotite	Sr–Rb	391 410	8
T, Boisdale Hills, Nova Scotia	[c]Post-Lower Devonian	Felspar Biotite	Sr–Rb	486	8
I, L. Dubuque Formation, Minnesota	Upper-Middle Ordovician	Felspar	A–K	390	10
R, Bentonite, Stone Rivers Group, etc.	Middle Ordovician	Biotite	Sr–Rb	451–496 ± 50	15
B, Dartmoor granite	Post-L. Westphalian, pre-L. or M. Permian	Biotite	A–K	305	Ox.
C, Oslo Alkali Suite	Stephanian or L. Permian	Biotite	A–K	308	Ox.
E, Land's End granite	Post-L. Westphalian, pre-L. or M. Permian	Biotite	A–K	340	Ox.
S, Cairnsmore of Fleet granodiorite	Post-Silurian, pre-L. Carb.	Biotite	A–K	470	Ox.
U, Shap adamellite	Post-Silurian, pre-L. Carb.	Biotite	A–K	475–510	Ox.
N, Mynydd Mawr microgranite	Lower–Upper Ordovician	Felspar	A–K	410	Ox.
		(70 per cent retention		550)	Ox.

(*a*) This may not represent the age of the formation in which the pitchblende is found; (*b*) the stratigraphy is probably less precise than this (Kulp, private communication); (*c*) see ref. 8 for an alternative stratigraphy.

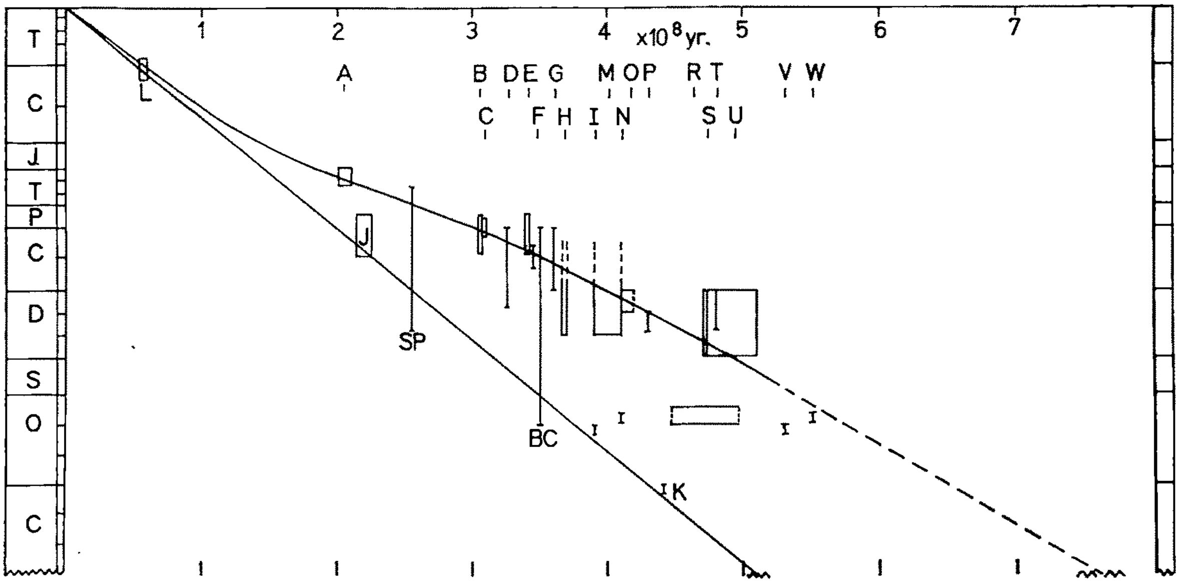

Fig. 1. Graph showing measured ages plotted against the stratigraphic column

Key. Holmes scale (on curves): *L* = Laramide orogeny; *J* = Joachimstal pitchblende; *SP* = Spinelli samarskite; *BC* = Bedford cyrtolite; *K* = Kolm

Other determinations:

A Chinle formation
B Dartmoor granite
C Oslo alkali suite
D Beryl Mountain pegmatite
E Land's End granite
F Franco–German Hercynian
G Georgia Piedmont
H Bear River, Nova Scotia
I Dubuque formation
M Nictaux Falls
N Mynydd Mawr microgranite
O Devonian bentonite
P Givetian of Saskatchewan
R Ordovician bentonite
S Cairnsmore of Fleet granodiorite
T Boisdale Hills, Nova Scotia
U Shap adamellite
V Dubuque formation, 70 per cent retention
W Mynydd Mawr, 70 per cent retention

All Oxford values estimated as ± 5 per cent, constants used being $\lambda_\beta = 0{\cdot}476 \times 10^{-9}$ yr.$^{-1}$; $R = 0{\cdot}123$.

The relative lengths of the geological systems are taken from the Holmes scale; the younger end of the curve is drawn to agree with data reported by Evernden (private communication).

within a few per cent. The reliability of the apparatus was checked by measuring the ages of previously determined samples obtained from the Department of Terrestrial Magnetism and by determining the argon content of atmospheric air. The atmospheric argon contamination and other possible impurities of the samples were checked mass spectrometrically. The precision and reproducibility of argon determination was better than 2 per cent. The potassium content was determined by flame photometry to approximately 2 per cent.

The results of our age determinations are given in Table 1. These samples have been chosen chiefly because their positions in the stratigraphic column are well defined. (We have found that other British granitic rocks belonging to the same petrographic provinces, but of doubtful individual stratigraphic assignment, give consistent results.) This has allowed us to draw the curve shown in Fig. 1, relating the geological age to the absolute age. In the past it has been customary in many cases to re-interpret any rather doubtful stratigraphy of samples measured, in order to fit them to the Holmes scale. Our results show a systematic divergence from this Holmes scale. In Table 1 we also give a number of published ages of samples for which the stratigraphy is less precise, in order to show their relation to our curve.

It is now seen that Faul's Hercynian ages, derived mainly from rubidium – strontium data, are compatible with the Dinantian–Namurian stages of the Carboniferous. The age values for Bear River and Nictaux Falls[8] would place these in the Devonian; field-evidence indicates that these granites intrude into lower Devonian[9], and so cannot be Ordovician as would be indicated by the Holmes scale. On our time-scale, the Boisdale granite was intruded into the early part of the Devonian.

Our age value of 410 m.y. for the Mynydd Mawr microgranite, which has been assigned to the Caradocian stage of the Ordovician, is to be compared with the measurements of Wasserburg and Hayden[10] on the upper-Mid-Ordovician Dubuque felspar. They dated this at 495 m.y.; which would be reduced to 390 m.y. if one uses the presently accepted nuclear constants in calculating the age. However, felspars are observed to have lost about 30 per cent of their radiogenic argon during their life-time[11], and allowing for this leakage both the Mynydd Mawr and Dubuque samples lie close to the new scale.

Damon and Kulp[19] have estimated the age of the Beryl Mountain formation, which is Upper-Devonian–Carboniferous[12], to be about 325 m.y., which agrees with the new scale. Measurements by Kulp and Long[13] of the metamorphic and igneous rocks of the Piedmont, using argon – potassium, rubidium – strontium and uranium – lead ratios, give an age value of 360 m.y. These were probably formed during the Permo-Carboniferous Appalachian orogeny, which places them on the new curve. Miller and Kulp[14] have reported that uranium – lead ratios of the Upper Triassic Chinle of the Colorado Plateau indicate an age of about 210 m.y.—once again higher than the Holmes Upper Triassic.

The recent measurements by Adams *et al.*[15] on an Upper Devonian bentonite lend further support to an extended scale. The value of approximately 410 ± 40 m.y. found from rubidium – strontium measurements is considerably higher than that which would be inferred from the Holmes scale; but it would fit well on the new scale. Two Middle Ordovician dates which they report fall roughly midway between the two scales.

The extended time-scale also has a bearing on the reported values of the diffusion coefficient of argon in sylvites of known stratigraphic age. The work of Gentner and his collaborators[16] on Oligocene sylvites from Büggingen and Alsace indicates a value of $D = 1\cdot5 \times 10^{-19}$ cm.^{2}/sec. at 40° C. This value has been criticized in detail by Folinsbee, Lipson and Reynolds[17] and Curtis and Reynolds[18], on the basis of measurements on an upper Middle Devonian (Givetian) sylvite. This sample had an apparent age of 285 m.y. from its argon-40 and potassium-40 content, while its true age was taken as 325 m.y. on the basis of the Holmes scale. Its deficiency in argon-40 was then explained by assuming loss by diffusion, with $D = 3 \times 10^{-20}$ cm.^{2}/sec. However, using the Gentner value for D gives an age of 430 m.y. for this salt, placing it correctly in the Devonian in our scale.

An extension of the Holmes time-scale appears necessary to explain the results given here. Unfortunately, intrusive granitic rocks cannot be placed within narrow limits in the stratigraphic column; hence the large spread in the ordinate values of the plots on Fig. 1. It may be that the relative extent of any particular system in the column is in error, so that a good fit to a straight line is not to be expected. The method of estimating maximum thicknesses of sediments, especially in the earlier stages, is open to question. In this connexion it would be particularly desirable to have some unambiguous dates in the Ordovician and Cambrian. To define the extent of any system in detail it is clearly necessary to have the ages of materials, as, for example, lava flows, known to be from the beginning and end of the system. We do not consider that the biotites have inherited argon. Faul's rubidium – strontium ages were in agreement with his argon – potassium dates. The granitic rocks we have dated come from widely varying geological environments with differing contents of potassium, history and petrogenesis. Furthermore, Damon and Kulp[19] conclude from measurements on calcium micas that primary argon is not a significant source of error in the argon – potassium method of dating.

Some evidence has been brought forward in support of Holmes's scale, notably by Gentner and Kley[20], who gave figures for felspars from the Hercynian of south-west Germany; and also by several workers who have analysed glauconites (for example, Wasserburg *et al.*[10] and the group working on the subject at the Massachusetts Institute of Technology[21]). Gentner and Kley's results ranged from 306 m.y. to 237 m.y. for the intrusive rocks of the Hercynian orogeny, which, assuming no loss of argon, agree with the Holmes scale for the Lower Devonian to the Lower Carboniferous. We have, however, found that felspars retain only 70–90 per cent of their radiogenic argon in this age-range; and if such a percentage loss occurs in the German samples, they would be compatible with our scale. The suitability of glauconite as a mineral for the determination of age has yet to be proved, as glauconite is a very variable mineral species, usually extremely fine grained, of unknown genesis and easily subject to subsequent recrystallization.

We are grateful to Mr. C. McInnes for carrying out much of the experimental work. This project forms part of the programme on geological age and isotopes at present being carried out in the Department of Geology and Mineralogy, Oxford.

Note added in proof. Prof. J. L. Kulp now informs us that measurements made on Kolm material taken several miles from the sill, and hence not thermally altered by it, show a discordancy similar to that previously found (to be published shortly); and loss of radon by diffusion may account for some of this discordancy.

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MARL: AN ANCIENT MANURE

By G. E. FUSSELL

ARTHUR YOUNG eulogized the custom of marling in 1769 in the following words: "All the country from Holkham to Houghton was a wild sheep walk before the spirit of improvement seized the inhabitants. . . . What has wrought these vast improvements is the marling; for under the whole country runs veins of a very rich soapy kind, which they dig up and spread upon the old sheep walks, and then by enclosing they throw their farms into a regular course of crops and gain immensely by the improvement"[1].

The process was well established when Young wrote the passage, and, according to his preface, had been initiated by Lord Townshend and Mr. J. Allen a good many years before. He made what might have been a more permanent record of this on his wife's tomb in Bradfield Combust church. Her obituary there states that she was the great-great-granddaughter of John Allen, Esq., of Lyng House in the county of Norfolk, the first person, according to the Comte de Boulainvilliers, who there used marl[2]. Only one farmer on the similar light land between Stoke and Thetford in Suffolk had bothered to use this method of improving his land in 1769. Much of the land in this area was then quite uncultivated, which surprised Young, because marl was to be found in many places beneath the sand[3].

The "Six Weeks Tour" was the first of Young's farming journeys, and was only incidentally concerned with agriculture. At that time he was inexperienced. He really knew little about the subject in which he was to achieve such great authority, and marling was new to him. He makes it clear that this method of reclaiming light land in part of Norfolk had been practised for some decades; but he does not give any explanation why John Allen first, and then Lord Townshend, should have begun to dig and spread marl if they, in fact, did initiate the process in that area. It may indeed have been something new there towards the end of the seventeenth century. More evidence is necessary to certify this, but it is quite certain that marl was used in other parts of the kingdom, and had been from at least the sixteenth century, and, possibly with some intermissions, from before the Roman occupation.

The word 'marl' has been used embracing a miscellany of earths dug out of the subsoil and spread upon the surface to increase fertility. Some of these subsoils have performed the function, notably clay spread on the fenland, but were not marl. Some typical marls, mixtures of chalk and clay, are derived from argillaceous limestones, such as some beds of Lias and Keuper. Marl containing carbonate of lime is far more valuable as a fertilizer than clay; it improves soil texture, adds carbonate of lime, potash compounds and sometimes phosphoric acid. Many light and blowing sands, like those that Young reported upon, have a bed of marl or clay near or beneath them, which can be readily obtained[4]. It is composed of a mixture of calcareous and other material in very varied proportions. Its precise definition is accordingly difficult.

The virtue of the material is said to have been recognized by the prehistoric Greeks, notably in Aegina, "where their use became a theme of mythology". Mineral fertilizers were found in their native states, either as earths like marl, or as deposits of alkaline salts like carbonate of lime, or nitrate of potassium (nitre), and mixing earths was first advocated by Theophrastus, according to Mrs. Semple. (She gives a modern interpretation, for I understand the Greek chemists did not know nitre.) It had the results set out by Sir Daniel Hall three millennia later. The Aegina surface stratum was a poor freshwater limestone underlaid by a stratum of fertile marl, which was dug out and laid on the surface to form a soil. The same thing was done in nearby Megara. Again, marl was a component of Tertiary Terraces[5].

Pliny, who disliked soil mixing, that is, sand on clay or clay on sand, confirms the use of marl in Megara, a marl-like white clay, and mentioned the different sorts by colour used in Britain and Gaul. They were the white, red, dove-coloured, etc. These were of two different qualities, acrid and fat. The white, often dug from deep pits, was that chiefly used in Britain. He made a distinction between that suitable for corn and for fodder crops, and estimated a rather exaggerated benefit lasting as long as eighty years. There was, however, no marl in Italy, and the Romans knew nothing of its use by experience. Varro, too, remarked the use of marl, a white fossil clay, as a fertilizer in Transalpine Gaul—*ubi agros stercorarent candida fossicia creta*—which Mr. Storr-Best had no doubt was the *Marne*, a natural mixture of lime and clay still used in France in 1912, and identical with the material used by the Greeks. Columella's uncle used it on his farm near Cordova, in Spain[6].

Between the fall of Rome and the thirteenth century there is a gap in the evidence. Whether marl continued to be dug and used in England during the centuries between is not known to me: but it is probable that it was used in France, and especially in Flanders. Oddly, it was on the clay lands there that marl was spread regularly and with excellent effect, because wet clay easily becomes sour, especially when the surface is little disturbed as in cereal growing. It was therefore necessary every few years to bring a heavy calcium concentration to these soils to neutralize the acidity. This was achieved by marling, which Lindemans justly describes as a remarkable piece of agricultural empiricism by a people who possessed no inkling of modern chemistry, but is quite contrary to the later English jingle:

He who marls sand
May buy the land;
He that marls moss
Suffers no loss;
He that marls clay
Throws all away.

In the Belgian sand land there is no early mention of marling, but the Flemish clay lands frequently have field names including marl and pits from which marl could have been dug before the end of the Middle Ages. Tenants in the area between Leuwen and Haspengouw were obliged by their leases to spread marl every so often, and the obligation continued. In other places marl was a complement, but not a substitute, for stall manure. The use of the material may have declined here with the increased production of stall manure, which it influenced indirectly by affording better yields of straw and fodder crops, but tenants who had insufficient dung were required by their leases to use it until the seventeenth and even the eighteenth century[7].

The open fields in Great Britain contained many disused marl pits in the early sixteenth century[8], and these may have been some centuries old. Walter of Henley was a protagonist of the manure in the thirteenth century. He thought the effects of marl lasted longer than that of manure, and indeed of earth and manure mixed, which was better than the simple dung. He advised spreading marl on the ground of the sheep fold every fortnight, and the anonymous "Seneschaucie", of about the same date, required the bailiff to "cause the land to be marled, folded, manured . . . as his knowledge may approve". The wagoner, too, ought to know how many times in the day the horses could go to carry marl or manure to the fields; some of this was repeated in "Fleta"[9]. These books can only be accepted as reflexions of the best practice of their day. They can scarcely have been speculative or imaginative works like those of so many of the later book-farmers, though it is possible they owed something to classical writings. Consequently, some medieval farmers in England were acquainted with the use of marl, and their use of the material was the cause of the disused marl pits noticed by Fitzherbert. He, too, was doubtless well read in such versions of the classical authors as were then available, and his ideas influenced by them. This must have been a pertinent reason why he deplored the stupidity of some early sixteenth-century farmers who neglected marl.

There was what seemed to them a sound economic reason for their action. They would not improve their land by this or any other process because they feared their landlords would demand higher rents immediately higher yields were gained. This was rather a silly line of reasoning; but no doubt it seemed prudent to them. Fitzherbert was convinced that marling well done would last for twenty years[10].

No doubt Fitzherbert had travelled through parts of England, and was well equipped to make accurate agricultural observations on what he saw. His statement that few open arable fields were then manured with marl is by so much to be accepted, but when Leland was in Shropshire, Cheshire and Lancashire, he found marl was used for ameliorating the poor sandy soils in those three counties, and he names specific places where the results were good[11]. Since these were counties where the convertible husbandry was practised in some places, that is, grass was ploughed for a few years cropping and then returned to ley, marling may have been continued from old times, or only been intermittently interrupted. It was certainly usual, not only in these three counties, but also in Somerset, Middlesex, Sussex and Surrey by the end of the sixteenth century[12], and this leads to the conclusion that it may have been habitual, almost traditional, in these areas.

Gervase Markham, writing in the first quarter of the seventeenth century, was a real enthusiast for marl. He recalled Pliny's statement that the Britons used it, and that it was mentioned in books of gainage or husbandry written in the reign of Edward II as well as by Walter of Henley. Markham himself describes how it was used by Kentish farmers when bringing areas of wealden land into cultivation. The quantity of marl used varied widely on different soils —as was wise. Marl was not, he said, good on clay land. On sandy or hazelly land 500 cartloads, containing 10 or 12 bushels each, could be usefully spread. The Kentish acre was 160 rods of 16 ft. After applying the marl, this land might be ploughed up and wheat sown, but some farmers broke up the grassland and took a crop of oats as was sometimes done during the recent war-time ploughing-up campaign. After this they spread the marl and sowed wheat. Land treated in this way must not be harrowed down fine. Only one or two crops were taken, and then it was let fall down to grass for five or six years. Markham rather optimistically said that "all this time it will beare a very good and sweet Pasture, well set with a white Clover, or, three leav'd grasse, most fatning and profitable, both for Sheepe and Bullocks". When the appropriate time had passed the ley was broken up again for two or three years crops. Under this system the effects of marling could be enjoyed for some thirty years, but if too many crops were taken it would be exhausted in five years. Was this the system employed elsewhere in the country where marl had continued to be used ? Very probably it was.

Four sorts of marl were found in the Weald, distinguished by their colour, grey, blue, yellow and red. Their order of merit was blue, yellow, grey, red. All were good material if as slippery as soap[13].

Whether marl continued to be used in France from the time when the practice was first observed by Cæsar's soldiers or not is difficult to say, but it seems probable. When Estienne and Liebault wrote their "Maison Rustique" in the sixteenth century they spoke of manure as either rotten dung or marl, and advised that the dung or marl be spread in the increase of the moon about November 18. Bernard Palissy, too, whose knowledge of soils was acquired during his researches into the best kind of clay for making pottery, included in his "Discours admirables" a chapter on marl, its value, how to recognize and where to find it. The familiarity with which these and other French writers deal with the use of marl suggests that it was generally used by French farmers when they were fortunate enough to find it[14].

Throughout the seventeenth century the English didactic writers continued to advise the use of marl, and the best way of doing so. Hartlib recorded that the men of Essex called the scourings of their ditches marl in the same way as pond mud was called 'Marle de mare' in a Waalse lease. Blith was sufficiently interested to carry out what must surely be one of the first comparative experiments in fertilizers. He used marl, pond mud, dung, and folk mucked two or three lands with each, and even had a control plot untreated. Of course he did not record the resulting yields arithmetically, but found the marl compared favourably with the other treatments, and fertilized nine years crops[15]. When the nascent Royal Society made its Georgical inquiry just after the Restoration it included in its questionnaire an exhaustive demand for information about the availability of marl, its depth, colour, the soils upon which it was used, and in what quantity, what time of year it was applied, and the crops which succeeded best on the land treated. How long its effect lasted was also asked, a question answered very variously from classical times onwards, but in his examination of the surviving returns Mr. Lennard does not say whether these questions were answered by any of the Society's correspondents. Unfortunately the Society was unable to secure a complete set of replies; but those that remain show that marl was then used in widely separated parts of Britain. In the Liberty of Ripon "Clay, Moorish and cold weeping grounds" were marled when broken for arable at 240 Winchester bushels the statute acre. Less was applied in other parts of Yorkshire, for example, in the Holme Beacon district. Marl was used in Devon and Cornwall as well as sea sand full of calcareous shells. Very heavy dressings were given in the "marl district" of Devon. Meadow land was marled in Wharfedale[16]. Evelyn had no doubt that relenting chalks or chalk-marl was a profitable fertilizer, and John Clayton informed the Royal Society that the tobacco growers of Virginia used only cow dung, although he had observed both red and blue marl at some breaks in the hills. In France, too, Louis Liger was a strong protagonist of marl, which was the best manure. Heavy dressings of 1,000–1,200 *voies* per arpent were given. The work was done in June or November, and, as elsewhere, the marl was left lying on the surface during the following winter so that it might be crumbled by sun, rain, snow and frost[17].

Even in Norfolk marling was being extensively practised by 1706, and had been on the Raynham Estate throughout the late seventeenth century. In 1731, at Holkham, 2,096 loads of marl were spread. Miss Naomi Riches supplies an ingenious explanation of the reason why it has been so often said that marling was abandoned from time to time and rediscovered[18]. The effects of the heavy dressings of marl were said to last for generations, from twenty to fifty, or eighty and a hundred years. Whether they did so is another question ; but the result of the long intervals that elapsed after a dressing of marl had been spread was that the new generation of farmers always regarded the process as one practised by its forefathers, and not presently current. Marling had therefore to be constantly revived. This is perhaps the explanation why it seemed so new and remarkable to Arthur Young, and that he and the Comte de Boulainvilliers thought it had been revived by Mrs. Young's great-great-grandfather, Mr. Allen.

On the Continent marl does not seem to have been subject to these intermissions. In Flanders it was superseded by the careful conservation of increased supplies of stall manure and animal urine plus town sewage and industrial waste, like rape cake. The reclamation of sandy lands was continued well into the nineteenth century, and was achieved by breaking through the iron pan beneath the sand, digging out the subsoil, stated to be "a stratum of loam", and spreading it upon the surface[19]. There was probably a mixture of calcareous material in this loam, but whether it was what we should call marl or not, I do not know.

The later history of the use of marl in England can be compressed into a paragraph. Throughout the eighteenth century the material was highly commended and extensively used at least by some farmers in many parts of the country. Change began with the introduction of bone manure, which soon began to supersede marl in Cheshire and the West Midlands. Early in the nineteenth century farmers were filling in the old marl pits and levelling the ground to increase the surface area of their farms. This was the beginning. The coming of manufactured and imported mineral fertilizers in the mid-nineteenth century did away with the need for the heavy labour involved in digging, carting and spreading marl, and the practice was abandoned once more, probably finally.

[1] Young, Arthur, "Six Weeks Tour", 2nd ed., 21, 22 (1769).

[2] Young, Arthur, "Six Weeks Tour", 2nd ed., viii (1769). "A Virginia Farmer", "Roman Farm Management", 83 (1913).

[3] Young, Arthur, "Six Weeks Tour", 2nd edit., 48 (1769).

[4] Hall, A. D., "The Soil. An Introduction to the Scientific Study of Plant Growth", 30, 232, 233, 256 (1903).

[5] Semple, Ellen Churchill, "Geography of the Mediterranean Region: its Relation to Ancient History", 380, 414 (1932).

[6] Pliny, "Nat Hist.", 17, 4, 7. Varro, 1, 7. Bradley, R., "A Survey of the Ancient Husbandry", 65, 66 (1725). Dickson, Adam, "Husbandry of the Ancients", 1, 344 (1788). Storr-Best, Lloyd, "Varro on Farming", 29 (1912). "A Virginia Farmer", 83.

[7] Lindemans, Paul, *Geschiendenis van de Landbouw en België*, 1, 43 (1952).

[8] Fitzherbert, "Surveying" (1523), in "Certain Ancient Tracts concerning the Management of Landed Property Reprinted", 82 (1767).

[9] Cunningham and Lamond (eds.), "Walter of Henley's Husbandry", 21,31,91,111 (1890). Cripps-Day, F. H., "The Manor Farm", 60, 70 (1931). cf. Lodge, Rev. Barton (ed.), "Palladius on Husbandrie" (M.S. of about 1420 A.D.). E.E.T.S., 28 (1873).

[10] Fitzherbert, "Surveying" (1523), in "Certain Ancient Tracts concerning the Management of Landed Property Reprinted", 82 (1767).

[11] Cited in Darby, H. C., "Historical Geography of England before 1800", 346 (1936).

[12] Norden, John, "The Surveyor's Dialogue", 227 (1607).

[13] Markham, Gervase, "Inrichment of the Weald of Kent" (1625), *passim*. cf. Markham's "Farewell to Husbandry" (1638).

[14] See translation of Surflet, Richard, "Maison Rustique or the Countrey Ferme", 669, 670 (*c.* 1600). This book first appeared in France in 1569. Sarton, G., "Six Wings: Men of Science of the Renaissance", 167 (1958).

[15] Hartlib, "Legacie", 3rd ed., 34 (1655). Lindemans, *op. cit.*, 48. Blith, Walter, "English Improver Improv'd", 138 (1653).

[16] *Phil. Trans. Roy. Soc.*, 1, 91, 94 (July 3, 1665). Lennard, Reginald, "English Agriculture under Charles II", *Econ. Hist. Rev.*, 4, 1, 32 (1932).

[17] Clayton, John, *Phil. Trans. Roy. Soc.*, 17, 984 (1693). Liger, Louis, "La Nouvelle Maison Rustique", 3rd ed., 1, 518 (1721).

[18] Riches, Naomi, "The Agricultural Revolution in Norfolk", 78 (1937).

[19] "Outlines of Flemish Husbandry", in vol. 3, "Husbandry" (Library of Useful Knowledge), 12 (1840). This follows van Aelbroek, "Agriculture de la Flandre" (1830), and is in turn followed by Rham, W. L., "On the Agriculture of the Netherlands", *J. Roy. Agric. Soc. Eng.* (1841, 1842).

SCIENCE AND TECHNOLOGY IN THE UNIVERSITY OF BRISTOL

OPENING OF QUEEN'S BUILDING

ON December 5, H.M. the Queen opened and named Queen's Building, which is to house the four Departments of Engineering, Civil, Mechanical, Electrical and Aeronautical, together with the Departments of Geology, Mathematics and Theoretical Mechanics in the University of Bristol.

Though the number of students concerned has been relatively small, the teaching of engineering and applied science in the University of Bristol has always been strong. Even before the days of University College, such men as William Smith, a founder of modern geology, John McAdam, the father of English roads, and Isambard Kingdom Brunel worked long in the district and influenced the rising generation towards careers in engineering. As a result, when University College was opened in 1876 it attracted to its staff young engineers and scientists of unusual calibre. Hele-Shaw and Stanton, both appointed before 1900, later became national figures in engineering, and the latter, as Sir Thomas Stanton, created the Engineering Division of the National Physical Laboratory. Silvanus P. Thompson, appointed for both "physics and electrotechnics", became a leader both in engineering education in London and in electrical engineering. W. J. Sollas, later translated to Trinity College, Dublin, and then to Oxford, was an outstanding geologist of international reputation. Between the World Wars there were among the engineering professors, Andrew Robertson and A. J. S. Pippard, both happily still very active. To this period belong also S. H. Reynolds and A. E. Trueman, who brought to geology a width of outlook and depth of local knowledge that made Bristol with its natural local advantages for geological field-work a well-known centre for the study of geology. In these inter-war years, also, the late H. R. Hassé, who was distinguished for his work in relativity theory and molecular physics, built up the Department of Mathematics from its early beginnings.

When Bristol received its charter in 1910, the Engineering Department of University College and the senior staff of the Technical College which had been maintained for many years by the Society of Merchant Venturers were brought together to form the Faculty of Engineering. It was housed in the buildings of the Technical College in Unity Street and was presided over, first by Dr. Wertheimer, and later by Prof. Andrew Robertson, as principal of the Merchant Venturers' College and dean of the Faculty of Engineering in the University. This arrangement was a source of strength to the Engineering Departments of the young University, but as time went on it was found unsatisfactory for the staff to attempt to cover the teaching of technicians and university students; also the laboratory space available was cramped and unsuitable for university work, with its increasing emphasis on research. While the University staff was freed from teaching in the Technical College in the years between the Wars,

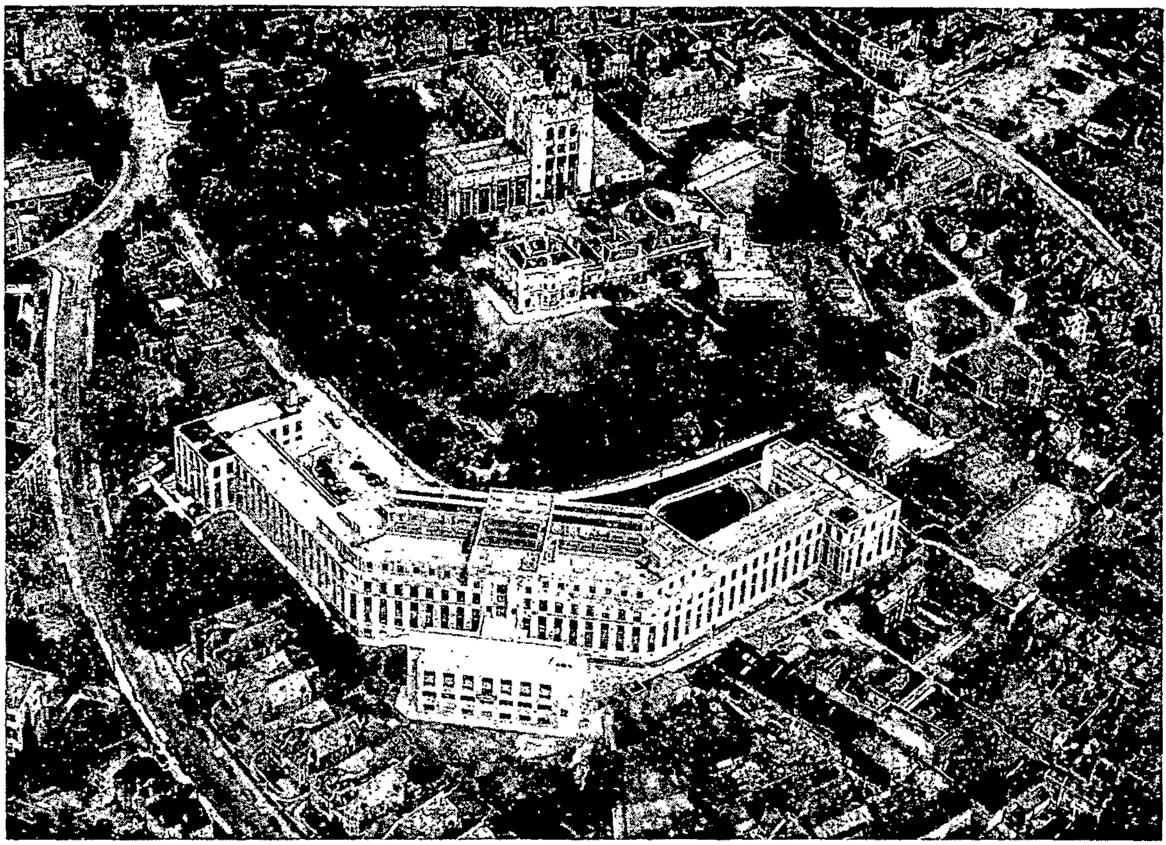

Photo: *Aerofilms Ltd.*

Fig. 1. Queen's Building, University of Bristol

and in the same period much first-class engineering research was produced, it is a matter for congratulation that the University, after forty years of invaluable help from the Society of Merchant Venturers, now has its Faculty of Engineering housed in the midst of the other University departments on an incomparable site, and in a building which gives the staff all the facilities they could desire for both teaching and research. The number of undergraduates now reading technology in Bristol is just under 350. It is to be hoped that with the opportunities now available the number will grow rapidly.

Queen's Building (see Fig. 1) stands on the southern brow of St. Michael's Hill just below the H. H. Wills Physics Laboratories. It has a commanding view over the city and docks of Bristol to the Somerset hills beyond. Construction was started almost nine years ago, and so goes back to the difficult days when labour and materials were in short supply. There is little to indicate this, apart from the fact that the framework of the building is of reinforced concrete, which gives a heaviness to many of the interior vistas. Some will find this pleasing, but it is a little out of keeping with the spirit of structural research in aeronautical and other fields, which has been during the past three decades, and still is, such a feature of Bristol engineering. The structure is lightened where possible by metal partitions and floor openings dictated by the specialist needs of the various departments. It was appropriate that in 1949 the first sod should be cut, incidentally using a mechanical excavator, by Prof. Andrew Robertson, at that time the dean of the Faculty of Engineering. It is very largely due to his outstanding work for the University over a period of thirty years, to his zeal and planning ability that the building exists to-day. With him was the architect, Sir George Oatley, senior partner of the Bristol firm of Oatley and Brentnall, which had been responsible for many Bristol buildings, including the University Tower and Library. Upon Oatley's death shortly afterwards, all the burden of architectural work fell upon his partner, Mr. Ralph H. Brentnall. Two Bristol contractors, John Perkins and Son and William Cowlin and Son, were responsible for the construction, the first for the preparatory work on the site and the second for the superstructure.

As will be seen from the accompanying photograph (Fig. 1), the building consists essentially of a large structure around an elongated courtyard, with two wings running from it east and west. It was the west wing and the western half of the central block that were constructed first. As soon as the foundation works for these had reached the centre of the building, the foundation stone to be seen beside the main entrance was laid on December 14, 1951, by Sir Winston Churchill, chancellor of the University, and at that time Prime Minister. The westerly parts of the building were completed in 1954 and at once taken into use, while work proceeded on the remainder of the central structure and on the east wing. At the same time, the Library building set on the hillside immediately before the southern front of the central structure was begun. It was finished in 1957 and the remainder of the work in 1958.

The building is approached by way of University Walk, with the gardens of the Royal Fort on the left and the Baptist College on the right. The main entrance leads directly to a spacious entrance foyer, in which will be noticed a plaque recording the special connexion between the Society of Merchant Venturers and the Faculty of Engineering. Like the walls around the entrance foyer, it is of gris mouchette, a marble-like limestone from northern France. The exterior is faced with a light-coloured brick from Cheshire with the principal features in Bath stone. Of the three main floors in the building, the lower ground floor is devoted to engineering laboratories: mechanical engineering in the west wing, aeronautical engineering in the east wing and civil engineering in the centre, with an additional laboratory under the Library. The ground floor, on the level of the main entrance, houses electrical engineering in the west wing and part of the centre, and the Department of Geology in the east wing. From the lower floors there is access to the Library which, with its gallery above, and stack room below, houses some 10,000 volumes and is designed to accommodate many more. On the first floor, lecture theatres and staff rooms occupy the centre block, with drawing offices, lecture rooms and tutorial rooms in the wings. At this level, also, the Departments of Mathematics and of Theoretical Mechanics are housed; the former, which serves the University as a whole, occupies much of the lecture room accommodation in the east wing, and the latter, which works primarily with the engineering departments, uses rooms in the west wing.

Further staff rooms are provided in a second floor which extends along the middle part of the building. Here also are some of the rooms set apart for postgraduate students.

It will be seen that the building gives all the departments within it new opportunities for extending or improving their equipment for both teaching and research purposes. In the field of civil engineering, the range of apparatus for the strength-testing of structures has been extended, and provision made for dynamic as well as static testing; and facilities for work on hydraulics and soil mechanics have been much improved. Better workshops, extended facilities for material and fatigue testing, and provision for the testing of gas turbines have become possible in the new mechanical engineering laboratories. The electrical engineering laboratories, in addition to extended testing equipment for general purposes, now provide several specially designed generator sets, which are the basic tools needed for research into problems in dynamo-electric machinery. The Department of Aeronautical Engineering, which owes much to the generosity of the Bristol Aeroplane Company in founding the Sir George White chair of aeronautical engineering some years ago, has several low-speed wind tunnels in operation, and more are planned. Compressors and a large high-pressure air reservoir are installed to provide for the operation of transonic and supersonic wind-tunnels. The Department of Geology has now adequate space for the display of its extensive collection of geological specimens, and has extended its laboratory work generally. All the Departments have been able, in addition to their teaching laboratories, to set aside proper space for research work.

There is no doubt that the provision of Queen's Building should enable Bristol to make an even greater contribution than it has in the past to the highly important field of technology and applied science.

J. F. BAKER

OBITUARIES

Prof. E. J. Maskell, F.R.S.

By the death of Ernest John Maskell on December 20 plant physiology in Britain has lost one of its most distinguished exponents.

Born in Cambridge on February 1, 1895, Maskell was educated at Cambridge County High School and the University of Cambridge, where he was a member of Emmanuel College. He graduated in 1919. With the award of the Frank Smart Studentship in 1920 he undertook research in plant physiology under the late F. F. Blackman. The results of this work on the diurnal rhythm of photosynthesis in leaves of cherry laurel in relation to carbon dioxide concentration, and on rates of photosynthesis in relation to stomatal opening, were afterwards published in the *Proceedings of the Royal Society*. After an appointment in 1922 to the Horticultural Research Station at Cambridge and a period at Rothamsted Experimental Station (1924–26), Maskell was appointed as plant physiologist at the Cotton Research Station in Trinidad. It was here, during 1926–30, that in conjunction with T. G. Mason he carried out the work by which he is best known and by which he is likely to be chiefly remembered, on translocation of carbohydrates, nitrogenous substances and phosphorus, potassium and calcium compounds in the cotton plant.

By 1930 Maskell's outstanding quality as an experimental plant physiologist was well realized and he was recalled to Cambridge to take up a lectureship, which was later raised to the post of reader in plant physiology. Here in the Cambridge Botany School for twenty-one years he was an inspiration to the many research students from Britain and overseas who had the advantage of his direction and supervision.

In 1951 Maskell was appointed to succeed me in the Mason chair of botany in the University of Birmingham. Just before his death he had been engaged in the troublesome task of developing plans for a new Botanical Department of the University.

Maskell was elected a Fellow of the Royal Society in 1939 and served on the Council of the Society during 1951–53. He was a member of the Agricultural Research Council during 1952–57 and represented the University of Birmingham on the governing body of Studley College from 1951 until his death. He was also a member of the governing body of the Grassland Research Institute, Hurley, a member of the executive committee of East Malling Research Station, of the Scientific Advisory Committee of the Empire Cotton Growing Corporation, and of the Advisory Panel of the Indian Tea Research Association.

Maskell was a life-long and active member of the Society of Friends and during the First World War served with a Friends Ambulance Unit. He was the most upright and kindest of men and those who had the privilege of his friendship held him in the highest regard. He married in 1923 Elisabeth Rose McCormick, who survives him. WALTER STILES

Prof. N. J. Scorgie

PROF. N. J. SCORGIE, Courtauld professor of animal husbandry in the Royal Veterinary College, London, died suddenly in his fiftieth year on February 10, 1958, in Iran, where at the instigation of the Food and Agriculture Organization of the United Nations he was conducting a mission related to re-organization and development of animal husbandry services. Jack Scorgie, as he was commonly known, was a 1929 arts and 1931 science graduate of Aberdeen, after which he took his veterinary diploma at the Royal Veterinary College and then joined the staff of that Institute. Following preliminary work in the Pathology Department and in preventive medicine, he transferred to the Department of Animal Husbandry, where he worked under Prof. W. C. Miller, whom he succeeded in 1946.

Scorgie had made the most of his wide training and was beginning to reap the benefit of his labours in organizing his Department, partly in new quarters, at the time of his death. He will be remembered best for his work on trichomoniasis in cattle, housing problems and poultry husbandry, being with the late Dr. Black, of Reading, the first to report on the successful applications of artificial insemination in fowls (*Gallus domesticus*).

NEWS and VIEWS

Plant Physiology at the Imperial College of Science and Technology : Prof. Helen K. Porter, F.R.S.

DR. HELEN K. PORTER, who has recently been appointed to the chair of plant physiology in the Imperial College of Science and Technology, London, is the first woman to hold a chair in the College. After graduating from Bedford College, London, in 1921, she spent a year in the Department of Organic Chemistry at the Imperial College, and was then appointed research assistant in the Department of Botany. Ten years later she joined the staff of the Research Institute of Plant Physiology attached to the Imperial College, and concentrated primarily on research in the field of carbohydrate metabolism. Shortly after the Second World War she spent a year in Washington University, St. Louis, studying enzymological methods. The subsequent development of her work, in collaboration with a group of colleagues and postgraduate research students with the support of the Nuffield Foundation, led to the opening in 1953 of an enzymology laboratory in the Institute of Plant Physiology, to accommodate a research group under Dr. Porter's direction. In 1956 she was elected to Fellowship of the Royal Society. In 1957 Dr. Porter was appointed to a new readership in enzymology at the Imperial College.

Burden Neurological Institute : Prof. F. L. Golla

PROF. F. L. GOLLA, director of the Burden Neurological Institute, Bristol, since 1939, is to retire. Prof. Golla, who followed Sir Frederick Mott as director of the Central Pathological Laboratory at the Maudsley Hospital, London, has for many years been a leading figure in neuropsychiatric research. Primarily a physiologist by training, his interests have extended into endocrinology, biochemistry, pharmacology and psychology, while his medicine has been constantly refreshed by gleanings in the German, French and Italian literature. His erudition is immense. In 1939 Prof. Golla moved to Bristol to start the Burden Neurological Institute, which, under his direction, has become widely known throughout the world.

Of Prof. Golla's research achievements, one of the most remarkable was his early application of the electroencephalograph to the study of neurological and psychiatric disorders, and, ably assisted by Dr. Grey Walter, he established the diagnostic value of the technique in cases of cerebral tumour and other lesions of the brain. He was also a pioneer in attempting the surgical treatment of epilepsy by the removal of epileptogenic foci, and played an important part in the development of electro-convulsive therapy. Many generations of students at the Maudsley Hospital remember with gratitude the inspiration of his lectures on the physiology of the nervous system. He has a style of his own and combines a keen critical capacity with a breadth of vision that is unique. In 1950 there appeared a volume entitled "Perspectives in Neuropsychiatry", which was published by old pupils and colleagues as a present for Prof. Golla's seventieth birthday. Always full of new ideas, he has found his pleasure and inspiration in his work and cares little for publicity or personal rewards.

Dr. W. Ross Ashby

DR. W. ROSS ASHBY, who now succeeds Prof. Golla, was previously director of the Research Laboratory at Barnwood House, Gloucester. He was educated at Cambridge and St. Bartholomew's Hospital and was at one time engaged as a pathologist at the Watford Peace Memorial Hospital and as a house physician at Bethlem. He is probably best known for his work on the 'homeostat', an electronic device designed to parallel the homeostatic mechanisms of the brain. His interest in the behaviour of neuronal nets led to the writing of the book, "Design for a Brain", which is very widely known.

Bell Telephone Laboratories Appointments : Dr. James B. Fisk

DR. JAMES B. FISK, executive vice-president of the Bell Telephone Laboratories, has been elected president as from January 1. Dr. Fisk succeeds Dr. Mervin J. Kelly, who has been elected chairman of the board of directors. Dr. Kelly has served as president of the Laboratories since 1951. Mr. Estill I. Green, vice-president in charge of systems engineering, is to be executive vice-president as from January 1.

Dr. Fisk, who has been associated with the Bell Laboratories for nearly twenty years, has combined a distinguished career in industrial research with outstanding service to the Government in the field of science. He was director of the Division of Research of the Atomic Energy Commission in

1947–48, and Gordon McKay professor of applied physics in Harvard University during 1948–49. He also served for six years on the General Advisory Committee of the Atomic Energy Commission. He is vice-chairman of President Eisenhower's Science Advisory Committee and has served on other government committees. He is a member of the U.S. National Academy of Sciences. He joined the technical staff of the Bell Laboratories in 1939, and during the Second World War he headed the Bell Laboratories group engaged in developing microwave magnetrons for high-frequency radar. After the War he was in charge of electronics and solid-state research.

Dr. M. J. Kelly

Dr. Kelly is one of America's leaders in the field of industrial research. He began his Bell System career in 1918 as a research physicist with the research division of the Western Electric Company's engineering department. This department was later incorporated as the Bell Telephone Laboratories. After serving as director of vacuum tube development and as development director of transmission instruments and electronics, he was elected director of research in 1936. He became executive vice-president in 1944 and president of the Laboratories in April 1951. He has had wide experience not only in research and development programmes relating to communications, but also in projects for the Armed Forces. In the course of the Second World War, the Bell Laboratories were devoted almost completely to military research and development programmes, all of which were under Dr. Kelly's guidance, and he was awarded the Presidential Certificate of Merit. Since the War he has held many public service appointments in Washington, particularly with the Atomic Energy Commission, the Department of Commerce and the Department of Defense. He is a member-at-large of the Defense Science Board. He has been awarded the James Forrestal Memorial Award of the National Security Industrial Association and will receive the 1959 John Fritz Medal for "his achievements in electronics, leadership of a great industrial research laboratory, and contributions to the defense of the country through science and technology". Dr. Kelly is also active in the field of education. He is a life member of the Massachusetts Institute of Technology Corporation and a member of its Executive Committee; a trustee of Stevens Institute of Technology; and serves on advisory committees at M.I.T., New York University, Case Institute of Technology, Columbia University, and the New York City Board of Education. He is a member of the New York City Health Research Council, a trustee and member of the corporation of Atoms for Peace Awards, a trustee of the Alfred P. Sloan Foundation and a member of the U.S. National Academy of Sciences.

Mr. E. I. Green

Mr. Green has a long record of distinguished engineering experience and achievement, including more than seventy patents granted for his inventions. He is also the author of many articles on scientific and personnel subjects. He began his career in 1921 with the American Telephone and Telegraph Company's development and research department, and with that department transferred to the Bell Laboratories in 1934. For many years he specialized in planning the development of new transmission systems, and services and facilities for special customers. During the Second World War he was engaged in development work on radar testing apparatus and other electronic equipment. He was appointed director of transmission apparatus development in 1948 and headed the development of systems components, including electronic components for transistorized systems. In 1953 he was elected director of military communications systems, in charge of planning and development in that area. He became vice-president of the Bell Laboratories in charge of systems engineering in June 1955. In that post he has been responsible for all Bell Laboratories work related to the systematic analysis and planning of future communications developments and systems.

The Royal Society: Tercentenary Celebrations

On November 28, 1660, a group of originally minded men meeting together in the City of London decided to form themselves into a scientific society. King Charles II, being informed of this, constituted himself the formal Founder, and the new society, now the premier scientific society in the world, came to be known as the Royal Society of London, or more generally, 'The Royal Society'. The Society, the apartments of which are now in Burlington House, Piccadilly, announces that it proposes to celebrate the tercentenary of its foundation during July 18–26, 1960, and a committee, with Sir Cyril Hinshelwood, president, as chairman, has begun to arrange appropriate celebrations to mark this event. Leading scientists from all nations are expected to attend the meetings, which are to include special visits to the City of London and the Universities of Oxford and Cambridge, both of which have important links with the Society's development over three centuries. The members of the Committee are: Sir Cyril Hinshelwood (*chairman*), Lord Adrian, Sir Gavin de Beer, Prof. P. M. S. Blackett, Sir Lawrence Bragg, Sir Lindor Brown, Sir Charles Dodds, Sir Alexander Fleck, Sir Howard Florey, Prof. W. V. D. Hodge, Sir Harry Melville, Sir William Penney and Dr. H. G. Thornton. The secretary to the Committee is Dr. D. C. Martin (assistant secretary of the Royal Society).

Nuffield Collection of Meteorites at the British Museum (Natural History)

A substantial part of Dr. H. H. Nininger's collection of meteorites, consisting very largely of falls hitherto unrepresented in British collections, has been purchased for the British Museum (Natural History) through a gift of £50,000 from the Trustees of the Nuffield Foundation, to celebrate the centenary of Prof. N. Story-Maskelyne's appointment as first keeper of minerals. To the 837 falls hitherto represented in the Museum, the Nuffield purchase adds a further 197, bringing the total to 1,034, or about 67 per cent of all known falls. Together with the 72 additional specimens of falls already represented, this greatly strengthens the reserves available for further exchanges. This large accession of meteorites is to be known as the Nuffield Collection. The British Museum's collection of meteorites is the largest and among the oldest in the world, dating back to 1776 when a specimen of the stony-iron found at Krasnojarsk, Siberia, was presented by the Russian Academy of Sciences. For many years the collection remained a relatively minor one, until Prof. N. Story-Maskelyne became the first keeper of minerals in 1859. A judicious series of exchanges and purchases soon improved the status of the collection, and when

G. T. Prior published his "Catalogue of Meteorites" in 1923 it held a clear lead over all others. In the past thirty-five years, the intensive search for meteorites sponsored by Dr. H. H. Nininger in the United States has resulted in a large number of new finds, but has also made the acquisition of new falls by purchase increasingly difficult for the Museum. Although a programme of exchanges with other museums has been vigorously pursued, the increase in falls represented in the British Museum has hitherto not kept pace with the increase in known falls. The scientific aspect of the Nuffield gift is of importance because meteorites constitute the only extra-terrestrial material available for detailed study, and an exact knowledge of their composition and structure is important for the cosmogony of the solar system.

Skomer Island as a Nature Reserve

WITH the co-operation of the West Wales Field Society, the Nature Conservancy is purchasing the island of Skomer as a National Nature Reserve. Skomer, 722 acres, is the largest of the islands off the Pembrokeshire coast. It is the landward edge of the ridge of varied igneous rocks of Ordovician age, jutting west from the mainland through Skomer to form Grassholm (famous for its colony of 10,000 pairs of gannets). Each year great numbers of sea-birds breed on Skomer, as well as a strong colony of the Atlantic grey seal. Probably the most notable breeding species is the Manx shearwater, a bird scarcely found on the mainland, but nesting in tens of thousands on Skomer and Skokholm. The puffin colony is, next to that of St. Kilda in the Hebrides, probably the largest in the British Isles. The island is also well known for the Skomer vole, which differs from the common bank vole in its larger size, extreme tameness and brighter colour. Skomer is being leased to the West Wales Field Society, which made an extensive field survey of the island in 1946, described in "The Island of Skomer" (West Wales Field Society, Orielton, Pembroke, 1950. 18*s*.). Persons requiring facilities on the island should communicate in advance with the Society, c/o The Hon. Warden, Orielton, Pembroke. Scientific investigations on the reserve may be arranged with the Regional Officer for South Wales of the Nature Conservancy, Department of Zoology, University of Swansea, Singleton Park, Swansea.

The British Steel Industry

POLITICAL and Economic Planning has rendered a real service by summarizing in Broadsheet No. 428 (November 28, 1958) "The Development of the Steel Industry", without entering into political controversy regarding ownership and control, the problems involved in planning the development of the industry whatever form of organization is finally adopted. The most important issue regarding the organization of the industry is simply whether one form of organization is better able than another to help the industry to provide the steel that is needed for the growth of the rest of the economy. Decisions will be required from time to time as to the total capacity of the industry and also detailed decisions on the building of individual plants. The former will have to be based on estimates of the growth of industrial production, which in post-war conditions are exceedingly difficult to make. The latter will continue to be influenced by assessments of future prospects for supply and demand, whether the industry is privately owned and controlled, or privately owned but supervised by an official board as at present, or both publicly controlled and publicly owned. Pricing policies will affect both the total demand for all kinds of steel and the demand for particular products. Location will be a matter of controversy because argument will continue that one location is better or worse than another not only on the grounds of productive efficiency, but also on account of the social issues involved in siting such large and vital industrial units. The development of the European Economic Community and the possible association of Britain with it will affect decisions about the capacity and location of the British industry, and particularly the question of the acceptance of some imports as against the objective of self-sufficiency in steel. These are the real economic issues, and questions of ownership and control are significant economically only in so far as they contribute to their solution.

Future of Television in Britain

SOME of the factors which should be taken into account when considering the future development of television are set out in a broadsheet, "Prospects for Television" (No. 427, October 31, 1958), issued by Political and Economic Planning. Without seeking to argue that a certain type of development should occur or to suggest who would be best able to undertake it, the broadsheet shows that there are many possibilities and that television in Britain need not be as limited as is sometimes imagined. The four remaining channels in Band 3 could be used to provide another television service for most of the country as soon as the Government decided to make them available (subject to available finance), but this would utilize all available very high-frequency channels and would reinforce the strength of present standards while leaving untackled the problems of higher definition and colour and of ultra high-frequency. It might also prevent the development of colour or higher definition on very high frequency, and would leave no room for parallel transmissions if further services were required. Two programmes could be provided on the remaining very high-frequency channels, each serving nearly two-thirds of the population, while allowing some local low-powered stations of Britain, but national coverage would not be achieved and there could be no further programmes or room for manœuvre. It is unlikely that the present very high-frequency channels or their limited extension will prove adequate for the future, and the main hope seems to lie in the development of the ultra high-frequency bands, which will leave room for a wider entry and allow a higher definition system and colour to be introduced when wanted. It should be possible to have quite a number of national and local television stations if they are wanted, and the proposed extension of the hours of television would permit the provision of a wider range of programmes for differing tastes but would add considerably to costs.

Nuclear Power Station on the Lleyn Peninsula

INTENSE opposition to the building of the nuclear power station at Edern in the Lleyn Peninsula is strongly brought out in the annual report of the Caernarvonshire Branch of the Society for the Preservation of Rural Wales. To protect the beauty and tranquillity of this rare and unspoilt coast, the National Parks Commission declared it an "area of outstanding natural beauty" on September 13, 1956; this was confirmed by the Minister of Fuel and

Power on May 27, 1957. Opposition to the new station is based not only on the despoliation of natural beauty but also because "the influx of workmen from outside, the rapidly changing levels of employment and its insecure basis, will upset agriculture and other stable industries by the uneven pattern of employment and create great disturbance". The Society's arguments have been set out in a specially prepared booklet, which can be obtained from W. Twiston Davies, Plas Hebog, Beddgelert, North Wales.

Curator

ALTHOUGH the museum profession is now attracting to its ranks more people than ever before, there are very few publications devoted to museology. For this reason alone the appearance of the quarterly periodical, *Curator* (1, No. 1, January 1958. Pp. 96. Annual subscription: 5 dollars), issued by the American Museum of Natural History, New York, is a welcome addition to the scanty literature. The days when a museum curator was a recluse, generally non-academic, are past, and the present-day official is relatively young, a specialist in a cognate subject and fully alive to the new demands of the public. There is thus no need for the editors to apologize for this new journal, and indeed the profession should be grateful to them for the initiative shown. A high standard of production was insisted upon for the first issue and this has been fully maintained throughout the year in the course of which ninety-four articles have been published, all of them of use to the curator who, unlike many of his academic colleagues, has to be proficient in a great variety of directions. *Curator* gives a general account of his activities, summarizes and reduces to print many of the thoughts in the mind of curators to-day and offers much information regarding new materials and techniques.

Maser Observations in Radio Astronomy

IN a paper presented at the one-hundredth meeting of the American Astronomical Society (and reported briefly in *Astron. J.*, **63**, 301; 1958), L. E. Alsop, J. A. Giordmaine, C. H. Mayer and C. H. Townes report what is possibly the first attempt to use maser techniques in radio astronomy. The maser amplifier is a three-level Bloembergen type, with a 0·1 per cent concentration of Cr^{3+} in ruby serving as the paramagnetic medium. The ruby crystal is mounted in a double resonant microwave cavity in liquid helium at 1·4° K. and in a magnetic field of 3,500 oersteds. The optimum signal-to-noise ratio for the system is obtained with a gain of about 20 decibels. The maser is used as a pre-amplifier and is mounted near the focal point of the 50-ft. reflector of the U.S. Naval Research Laboratory. The results obtained show an improvement factor of about ten in signal-to-noise ratio over the same installation without the maser pre-amplifier, in accordance with the expected low noise characteristics of maser amplifiers. Observations were made of Venus, Jupiter and the nebula NGC 4486, and they demonstrate the feasibility of applying maser techniques to radio-astronomical observations.

Permanent Graticules

WORK at the Reference Standards Laboratories of the Australian Commonwealth Department of Supply has culminated in the introduction of a new method for the production of graticules, known as the 'interstitial graticule' process. The method employed is of considerable interest, and the product will undoubtedly find a number of applications, particularly in cases where permanence is the prime requisite (*Aust. J. App. Sci.*, **9**, 207; 1958). The desired pattern is first produced on the surface of the glass. By a process of electrolysis at an elevated temperature the pattern is transferred in ionic form below the glass surface. Subsequent treatment involving chemical reduction converts the 'ionic' image to metal and the graticule pattern then becomes readily visible and is as stable as the glass itself. By suitable choice of metal and conditions of processing the final pattern may be black or coloured, transparent or opaque. The inventors of the process, A. J. C. Hall and J. C. Hayes, have recently been awarded the Waverley Gold Medal and Prize by the journal *Research* for an essay on their work.

Records of Nodulation in *Coriaria*

IN referring to the root nodules borne by *Coriaria* spp. (*Nature*, **182**, 474; 1958), Dr. Bond commented that although their occurrence in New Zealand is known, there seem to be no records in the literature. Mr. R. E. R. Grimmett (formerly superintendent of the Rukuhia Soil Research Station, Hamilton, N.Z.) has directed attention to an article, by him, using the pseudonym "Cryptos" and published in the August 1944 issue of *Forest and Bird*, the journal of the New Zealand Forest and Bird Protection Society. Under the title of "The Much-maligned Tutu"—the latter being the Maori name for *Coriaria* spp.—Mr. Grimmett recorded the regular occurrence of nodules on a species of *Coriaria* (now identified as *C. arborea*) in the Wairarapa district, and testified to the faculty of this and other species of the genus for colonizing raw mineral soils and improving fertility, facilitating the eventual establishment of forest. Like Dr. Bond, Mr. Grimmett referred to the paucity of native legumes in New Zealand and envisaged the possibility that *Coriaria* has been a main native source of biologically fixed nitrogen in that country. The field observations which he cited are in excellent accord with such results of laboratory experiments as are available.

International Grassland Congress

THE eighth International Grassland Congress will be held in Reading during July 11–21, 1960. Reading will prove to be a very appropriate town, since it is within easy reach of several important centres of agricultural research. Pre-Congress tours of grassland areas and research institutes are being planned. The main problems to be discussed are: pasture management and fertilizing; plant breeding and genetics; conservation—recent developments; problems of tropical grassland; estimation of grazing intake; biochemistry of pasture plants; hormone stimulation of grazing animals; special statistical techniques. The organizing committee is commissioning the majority of papers to be presented to the Congress, but it will also consider requests from research workers who wish to present papers of particular interest. Further information can be obtained from the Secretary, Eighth International Grassland Congress, Reading, Berks.

Symposium on Interferometry

AN international symposium on interferometry is to be held at the National Physical Laboratory, Teddington, Middlesex, during June 9–11. The symposium is intended for specialists and will not deal primarily with technical applications. There will be four half-day sessions devoted to the presentation of papers and to discussion, and a fifth session for demonstrations. About twenty main papers have been invited and will be printed and circulated in advance. Additional short contributions will be welcomed in the form of contributions to the discussion on the main papers, or in the form of demonstrations. The main papers, the discussions, and notes on the demonstrations will be collected and published after the symposium in one volume. Attendance is by invitation; applications should be made to Mr. L. H. McDermott at the National Physical Laboratory.

University News: California Institute of Technology

A GRANT of 73,594 dollars from the U.S. National Foundation (formerly the National Foundation for Infantile Paralysis) has been made to Dr. Renato Dulbecco who, with Dr. Marguerite Vogt, is investigating virus inheritance in experiments involving polio virus mutations. Another grant, of 33,943 dollars, has been made by the National Foundation to Prof. Linus Pauling, for investigations on the structure of nucleic acids.

Nottingham

THE University of Nottingham has received an offer of £100,000 from Rolls-Royce, Ltd., to endow a chair of thermodynamics in the Faculty of Applied Science. This chair is to be established by the Company in recognition of Lord Hives's contribution to engineering science, and will be known as the Hives chair of thermodynamics. It is hoped to encourage the training of an increased number of technologists and the development of a strong research school in thermodynamics. The University plans to increase its output of mechanical engineers by 250 per cent in 1965, and new laboratories to make this possible are under construction. One of these new laboratories will accommodate thermodynamics, fluid mechanics and heat transfer and occupies some 30,000 sq. ft. The new professor will be responsible for these laboratories and the development of researches in these fields.

Announcements

THE Council of the Institution of Mechanical Engineers has awarded the 1959 James Watt International Medal to (the late) Sir Claude Gibb as an engineer who achieved international recognition both by his work as a mechanical engineer and by the ability with which he applied science to the progress of mechanical engineering.

DR. MAX A. LAUFFER, professor of biophysics and dean of the Division of Natural Sciences in the University of Pittsburgh, has been awarded the 1958 Pittsburgh Award of the Pittsburgh Section of the American Chemical Society. Recently his main researches have been on the hydration of viruses and proteins, and the relationship between their physical, chemical and biological properties.

MR. A. BARCLAY, keeper of the Department of Chemistry, and Mr. E. W. White, deputy keeper in the Department of Aeronautics in the Science Museum, South Kensington, are to retire on March 31. Dr. S. E. Janson, deputy keeper in the Department of Chemistry, has been appointed keeper, in succession to Mr. Barclay and Mr. F. Greenaway and Mr. W. Winton have been appointed deputy keepers from April 1.

A TRANSLATION Service has recently been set up by the Iron and Steel Institute with the collaboration of several large companies and of the British Iron and Steel Research Association. The Service is open to both members and non-members in Great Britain and abroad. Some 530 translations are already available, a large proportion of them from German or Russian, and a classified list of the translations made in the first year is now available; it is kept up-to-date by fortnightly lists (with classified cumulations every six weeks). Inquiries should be addressed to the British Iron and Steel Industry Translation Service, Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1.

A course for senior technical executives in industry is being held at the Harwell Reactor School during June 15–25, the fee being 50 guineas. Forms of application and further details can be obtained from the Reactor School, Atomic Energy Research Establishment, Harwell, near Didcot.

A SYMPOSIUM on Boundary Problems in Differential Equations, with especial reference to recent developments in this field, will be held by the Mathematics Research Center, United States Army, at the University of Wisconsin during April 20–22. Further information can be obtained from R. E. Langer, Director, Mathematics Research Center, U.S. Army, 1118 West Johnson Street, Madison 6, Wisconsin.

A CONFERENCE on Electrically Exploded Wires, sponsored by the Thermal Radiation Laboratory of the Geophysics Research Directorate of the U.S. Air Force Cambridge Research Center, will be held at the Somerset Hotel, Boston, Massachusetts, during April 2–3. Invited and contributed papers on both theory and uses of exploding wires will be presented. Further information can be obtained from W. C. Chace, Thermal Radiation Laboratory, CRZCM, Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Massachusetts.

THE English Electric Valve Co., Ltd., is holding an exhibition at the Kensington Palace Hotel, London, during March 17–21. The display will be devoted to modern valve design technique in the fields of radar, communication, transmitting, broadcasting—both sound and vision—and instrumentation, together with new types of storage tubes. Further information can be obtained from A. J. Thoroughgood, English Electric Valve Co., Ltd., Waterhouse Lane, Chelmsford, Essex.

A SPECIAL short course in Stereospecific Polymers and Block and Graft Co-polymers is being held in the Department of Chemical Technology of the Bradford Institute of Technology on February 27 and 28. Prof. C. E. H. Bawn will lecture on the preparation of stereospecific polymers; Dr. I. Goodman on stereochemical structure and polymer properties; Dr. C. H. Bamford on the preparation of block and graft co-polymers; and Dr. W. Cooper on the properties and uses of block and graft co-polymers. The fee for the course is 45*s*. Application forms can be obtained from the Registrar, Institute of Technology, Bradford.

ERRATUM. In the communication entitled "Penicillin Derivatives of *p*-Aminobenzyl Penicillin" in *Nature* of January 17, p. 180, the units throughout should be "u./ml.", not "μ/ml." as printed.

MECHANIZATION OF THOUGHT PROCESSES

A SYMPOSIUM entitled "The Mechanization of Thought Processes" was held at the National Physical Laboratory during November 24–27. About two hundred invited delegates came from thirteen different countries to listen to, and discuss, papers on a wide range of topics related to 'artificial intelligence'. Associated with the symposium was an exhibition of devices and machines related to the general theme.

Dr. M. L. Minsky, of the Massachusetts Institute of Technology, gave the opening paper, which was concerned with "Heuristic Programming". Heuristic methods can be distinguished from the straightforward methods of solving a problem by the fact that they cannot be guaranteed to work. They are not 'algorithms'. The paper dealt with programmes for computers rather than with special machines, because any machine that can be fully specified can certainly be simulated on a digital computer, and trials by computer are less expensive.

The special features of heuristic methods discussed were 'pattern recognition', 'learning', 'planning ahead' and the use of analogies or models. These features were illustrated by a proposed programme for proving theorems in Euclidean geometry, where the model consists of actual constructions of points and lines. When tried out on the theorem that 'the base angles of an isosceles triangle are equal', it provided an unusual proof, using the congruence of the triangle to its mirror image.

There were two other papers on the general principles of intelligent machines, by Dr. D. M. MacKay, of King's College, London, and Dr. J. McCarthy, of the Massachusetts Institute of Technology. Dr. MacKay's paper examined the problems of obtaining intelligence in machines, and of evaluating it and distinguishing it from mere ability to calculate. He was led to the conclusion that one needed a hybrid system consisting of a digital decision process with an analogue process for evaluating 'weight' of information and proximity of a solution, etc. Several of the later papers concerned such devices.

Dr. McCarthy described a computer programme which he is developing, called the 'advice taker'. This programme, when given a set of statements about the world, is intended to deduce conclusions about action to be taken. In the discussion, some speakers felt that the proposed 'machine' would be too logical, and that practical decisions are not made in this way. It was agreed that the final answer would be given when the programme could be shown to work, or not, as the case may be.

It is not possible to describe here all the papers that were read and discussed. They can perhaps be divided into four groups, and some from each group will be mentioned. The groups are: (1) proposed mechanisms for intelligent machines, not necessarily related to neural mechanisms; (2) proposed mechanisms for intelligent machines which bear some relation to what is known of neural mechanisms; (3) the lessons to be learnt from the study of perception; (4) a number of related topics and applications.

Perhaps the most interesting mechanisms discussed at the symposium were those that attempted to reproduce some of the known constructional features of the brain. They were contained in papers by Dr. A. M. Uttley, of the National Physical Laboratory, Dr. F. Rosenblatt, of Cornell Aeronautical Laboratories, and Dr. W. S. McCulloch, of the Massachusetts Institute of Technology.

Dr. A. M. Uttley's 'conditional probability computer' embodies a classifying network, or 'tree', and a set of counters to record the number of instances of each possible state of the input channels. These counts are recorded in a logarithmic scale, so that their differences represent the logarithms of estimated conditional probabilities. The conditional probabilities are used to infer patterns at the input when only part of the pattern has actually been presented to the machine. In the paper presented to the symposium, this work was developed by considering how neural networks, with their connexions in some respects random, could perform in a way similar to the highly organized electronic model.

Dr. F. Rosenblatt described recent theoretical work on the behaviour of the 'perceptron'. This is a 'neural' network in which a large population of 'neurons' have random connexions to the inputs, and their connexions to the outputs are paralleled by feed-back connexions which modify the parameters of the 'neuron' so that frequent stimulation of an output will reinforce the neurons which feed this output. The hypothetical neurons assumed by Rosenblatt obey linear equations, for convenience; but computer simulation has shown that they would work with a wide range of characteristics.

Dr. W. S. McCulloch's paper was concerned with hypothetical neurons working with binary signals, and with a threshold—the well-known 'Pitts and McCulloch' neurons. It did not attempt to describe what happens in the brain, but explored switching circuit design using these particular switching elements. The problem considered was how to make switching circuits which are insensitive to variations of threshold.

Dr. O. G. Selfridge, of the Massachusetts Institute of Technology, described a process which was not related to neural mechanisms, but which would adapt and improve itself to handle recognition problems. The process, called a 'pandemonium', was described in rather anthropomorphic terms, but this was perhaps less obscure than an abstract description would have been. The pandemonium contains an assortment of 'demons' each responsible for looking out for a particular feature in the input. Some demons may look for features in the output of lower demons. At the highest level in the system, the strongest output of any demon is detected by a decision demon. Processes were described for inventing demons, making them more or less powerful according to experience, and so forth. A practical example is under development; this is a pandemonium for the translation of manually keyed morse.

A very interesting paper by Dr. Ross Ashby, of Barnwood House Hospital, Gloucester, showed that habituation can be demonstrated in a mechanism without any detailed assumptions about its construction. The only assumptions made were of a behavioural kind. By habituation is meant the decrease of response to a stimulus when it is regularly repeated. An indication was given of the circumstances in which extraneous disturbances could cause de-habituation.

Among the several papers giving the point of view of biologists was one by Dr. H. B. Barlow, of the

University of Cambridge, which treated the coding of signals in sensory mechanisms. There is evidence of mechanisms operating at low levels in sensory pathways to reduce the amount of redundancy in the vast number of parallel information channels. Unlike the recoding proposed by Shannon for communication channels, the aim is not to remove all redundancy, but to reduce the number of pulses on any given channel, and to reduce correlation between channels. For two binary channels, the specification of such a coding device is very simple, and a model of this device was shown in the exhibition.

Among the specialized topics discussed was automatic programming, to which a morning's session was devoted. Dr. Grace Hopper, of Remington Rand, Ltd., gave the opening paper, and the session was rounded off by a paper from Dr. A. P. Ershov, of the Academy of Sciences of the U.S.S.R.

An afternoon's session was devoted to mechanical language translation, and Dr. Ershov, at short notice, said something about the groups working on this subject in the U.S.S.R.

Unusual fields for mechanization formed the subject of several papers. Dr. L. Mehl, of the École Nationale d'Administration, Paris, spoke on automation in the legal world. He described a machine for retrieving legal information and a machine for legal argument. The limitations of such machines are that they are incapable of evaluating data, or of developing the principle of law, so they cannot be a substitute for the jurist.

Dr. F. Paycha, of Paris, spoke about the logical structure of medical diagnosis, emphasizing the vast volume of facts on which it is based, and the need for mechanization to reduce the chance of an error. In the discussion which followed, the question was raised of how far probability considerations should be allowed to influence diagnosis.

Speech recognition was the subject of two papers. Prof. D. B. Fry and Mr. P. Denes, both of University College, London, described how linguistic information has been brought into the problem of speech recognition. A machine capable of handling 13 English phonemes and using digram frequencies to make a decision was shown in the exhibition. A paper by Mr. P. Ladefoged, of the University of Edinburgh, reviewed the whole field of speech perception, making the particular point that speech is not, in any sense, a sequence of small discrete elements.

In the analogous field of visual pattern recognition, a paper was read by Dr. W. K. Taylor, of University College, London.

Other papers dealt with literature searching, the mechanization of administration, and learning in animals, in addition to the subjects mentioned above.

The general impression given by the symposium was that in none of the fields of study is there any finality as to the basic approach to the problem. In the field of intelligent machines, there was a wealth of suggestions, but none of these has yet reached the stage of a successful test. It was also evident that many suggestions that can be made for machines to solve problems or perceive patterns may fail because the number of individual units in the machine is too large and that any practical machine must include some trick to achieve economy of equipment.

The modern theory of automata began with A. M. Turing's proof that universal computing machines were possible. Dr. Turing's ideas, and those of J. von Neumann, led to the construction of electronic computers, which are the working tools of the experimental approach to artificial intelligence. It seems possible that a further great advance in the development of intelligent machines will soon be made.

The *Proceedings* of the symposium, including the papers read, together with the discussion, will be published by H.M. Stationery Office in due course.

D. W. DAVIES

DEVELOPMENT OF ELECTRIC CABLES

MR. S. E. GOODALL delivered his presidential address before the Institution of Electrical Engineers on October 9. His subject was electric cables, and a substantial part of his address was devoted to reviewing the history of their development.

It was in the year 1812 that the first experiments were made in applying a soluble material, said to be india rubber, to the insulation of copper wires. The great initial development of the electric telegraph took place as a means of inland communication and the circuits employed were almost wholly composed of overhead, open-wire, lines. It was the timely discovery of the excellent properties of gutta percha as an insulant and its practical application to electric cables by Werner Siemens that initiated the development of submarine telegraph cables and indeed of cables generally. The year 1851 saw the first cross-Channel cable in operation, and fifteen years later the first successful telegraph cable spanned the Atlantic Ocean. The pioneer of the electric power cable was Sebastian de Ferranti. The transmission of power by alternating current at 10,000 volts from the Central Station at Deptford to the West End of London was effected by concentric cables of entirely novel design. Oil-impregnated paper was the dielectric, and the type of construction devised by Ferranti remained the basis of high-voltage power cable design for half a century. By 1900 single-core and three-core impregnated paper lead-sheathed cables were in regular manufacture in Britain.

The manufacture of telephone cables developed rapidly from about 1890. Multi-circuit lead-covered cables when first introduced were filled with insulating material such as paraffin wax, but their electrical characteristics were soon greatly improved by the adoption of the dry-core technique, in which advantage is taken of the air interstices to obtain lower electrostatic capacitance. The first cables used for long-distance telephony were simply adaptations of telegraph cables and used gutta percha as a dielectric. For gutta percha, balata was later substituted and this held the field for submarine purposes until comparatively recently.

Two very important developments in high-voltage power cables occurred during the 1920's. The major factor tending to initiate breakdown in high-voltage cables had been traced to ionization in voids in the dielectric, and the formation of voids had been demonstrated to be associated with the thermal expansion and contraction of cables under varying conditions of load. Improved design and better techniques of impregnation proved to be insufficient to remove the inherent electrical weakness resulting from heating cycles. The first effective remedy was devised by Emanueli, who, in 1920, employed a thin mineral oil as a liquid impregnant applied under pressure from reservoirs at predetermined points in the cable system. An alternative method of suppressing ionization in voids, invented at about the same time, was the use of an inert gas at high pressure. This development did not proceed very rapidly and was seriously interrupted by the Second World War. There are, however, now many important installations of super-tension gas pressure cables.

The distribution of electricity in buildings was first effected by wires insulated with paraffined cotton, but it was not long before rubber was adopted as the insulant. Some indication of the early rate of development of the distribution of electricity to domestic and industrial premises is given by the fact that in 1882 the Society of Telegraph Engineers and Electricians issued their first "Rules and Regulations for the Prevention of Fire Risks from Electric Lighting".

Although the techniques of cable manufacture were being steadily developed and improved, there had been, up to the outbreak of the Second World War, little change in the basic materials and processes. During the Second World War and since, very far-reaching changes have taken place. Plastics and synthetic rubbers have been introduced, some of these materials having excellent electrical characteristics together with satisfactory mechanical properties, and a substantial proportion of the electric cables now manufactured employ these new insulants. It was the development of radar during the Second World War that evoked the urgent demand for cables which would transmit satisfactorily very high-frequency currents, and polythene was the material which enabled this demand to be met. The drastic reduction in the available supplies of natural rubber which developed as the War progressed was the incentive in the search for synthetic substitutes. Polyvinyl chloride, commonly known as P.V.C., is a war-time product which is now firmly established in cable-making practice.

In addition to the introduction of new insulating materials there have been, since the end of the War, important developments in manufacturing methods. As an example of this may be cited the new method of coating wires known as continuous vulcanization. A well-established method of applying the rubber covering to wires involves the continuous interleaving of a group of wires moving longitudinally in parallel between two thin ribbons of rubber. The passage of this layered ribbon between suitably grooved rollers produces individual insulated wires with, of course, seamed coverings. The modern alternative to this is known as continuous vulcanization.

In this process rubber compound is forced on to the wire as a seamless cylindrical coating in the extruding 'head' of a rotary-screw extrusion machine through which the wire is passing at fairly high speed. Immediately on leaving the head the covered wire is passed into a long well-lagged steel tube which contains high-pressure steam, and in this vulcanization takes place. In this process the finished core is produced to very close tolerances by the extensive utilization of electronic methods of automatic control.

Direct extrusion methods are employed for the covering of cables insulated with polyvinyl chloride and polythene. It is not practicable to use, for these synthetic materials, the same machines as are used for natural rubber coatings, but plants designed for polyvinyl chloride can with relatively slight modification be utilized for polythene.

Some important advantages, other than those of improved electrical characteristics, are associated with the use of the new plastics, but there are also limitations.

Polyvinyl chloride has good mechanical properties and, in addition, is strongly resistant to corrosion. For this reason it is used as an external, serving to protect from the corrosive effects of soil waters or of acids such as those produced when textile servings rot through bacterial attack. Wire insulated with polyvinyl chloride or polythene, however, is not capable of withstanding as great an electrical overload as can be tolerated by conductors insulated with vulcanized indiarubber. Ordinary grades of polythene melt at a temperature slightly above 105° C. Polyvinyl chloride, while it has no sharp melting point, becomes softer as the temperature increases and may suffer severe deformation under mechanical stress. The thermal characteristics of polythene can be considerably improved by exposing the material to neutron or electron bombardment. Such treatment effects cross-linkage between the molecular chains in its structure. This eliminates the sharp melting-point and the material becomes rubber-like at about 150° C. Irradiation is, however, expensive, and it appears unlikely that irradiated polythene will be available except for special applications.

Another important synthetic material is silicone-rubber. This material will operate indefinitely at 150° C. and flexibility is retained down to − 70° C. Its electrical properties are similar to those of natural rubber. Cables insulated with silicone-rubber have the unique property that, if exposed to fire, the residue of the insulation is largely pure silica, and after a fire such cables can be operated temporarily provided they are not disturbed.

Mr. Goodall's address ended with a brief review of the technical possibilities and objectives of cable making in Great Britain. The trend towards greater use of plastic materials would, he thought, undoubtedly continue, and there would probably be continued effort towards such reductions of dimensions as might be rendered possible by improved process control methods.

To be able to face intensifying competition from abroad both in the home and export markets, the industry must be prepared to face the consequences of rationalization of production, with consequent regrouping of manufacture and co-operation in one form or another among the different companies concerned. Cable users, on the other hand, must be prepared, in their own and in the national interest, to accept some measure of restriction of choice. The two bugbears of cable making are alternatives and variety, and the industry as a whole possesses surplus plant for many operations, although few if any of these operations are wholly obsolete. In effect, standardization must be directed towards the elimination of unnecessary complication rather than the inclusion of all the variants for which there might be a demand.

James Greig

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION, AUSTRALIA

CHEMICAL RESEARCH LABORATORIES

THE Commonwealth Scientific and Industrial Research Organization (Australia) has changed the status of one of its largest research groups, the Division of Industrial Chemistry, which has its headquarters at Fishermen's Bend, Melbourne. The Division will in future be known as the C.S.I.R.O. Chemical Research Laboratories, and its chief, Dr. I. W. Wark, becomes the first director of the Laboratories. Two of the largest Sections of the Laboratories will become Divisions (the name used for the major units of C.S.I.R.O.'s activities). Dr. A. L. G. Rees will become chief of the new Division of Chemical Physics and Dr. K. L. Sutherland will become chief of the new Division of Physical Chemistry.

These two new Divisions together with the remaining four major Sections will comprise the Chemical Research Laboratories. These sections and their officers-in-charge are as follows: Minerals Utilization (Mr. R. G. Thomas); Organic Chemistry (Dr. H. H. Hatt); Cement and Ceramics (Mr. A. J. Gaskin); Chemical Engineering (Dr. H. R. C. Pratt). The Foundry Sands Section will continue to be affiliated with the group.

Dr. Wark has been chief of the C.S.I.R.O. Division of Industrial Chemistry since its formation in 1940. Under his guidance this group has grown until it now has a research staff of one hundred and a total staff of three hundred.

More than a third of the research staff has been recruited from overseas, and about half of the Australians have studied abroad for higher degrees.

An adventurous outlook on research within the Chemical Research Laboratories has produced outstanding contributions in many phases of chemical discovery, both in basic science and in the solution of practical problems.

Some of C.S.I.R.O.'s more spectacular applications of science have come from the Chemical Research Laboratories. These include the process using cetyl alcohol for controlling evaporation from dams and reservoirs; the process for separating hafnium from zirconium which is of significance for atomic-powered submarines; and a process for recovering uranium from its ores.

Dr. Wark's own personal research was concerned with the theory of the flotation process for separating minerals from ores, which is of major importance to the mining industry. His pioneering work as a physical chemist in this field gained for him a worldwide reputation, and his book, "Principles of Flotation", first published in 1938, became recognized as a classic on the subject. He is a Fellow of the Australian Academy of Science. For many years he has taken a prominent part in the affairs of the Royal Australian Chemical Institute and has done much to gain a wider appreciation of the importance of chemistry and of science generally. He served as president of the Institute during the year 1957–58.

Dr. A. L. G. Rees, chief of the new Division of Chemical Physics, began his scientific career with a brief temporary lectureship in the University of Western Australia; then he became Beit Fellow at the Imperial College of Science and Technology, London. In 1941 he was awarded the Ph.D. of the University of London and joined the Philips organization in England as head of the Fundamental Research Group. He held this post until 1944, when he was appointed to C.S.I.R.O. to form the Chemical Physics Section. He has undertaken research into the structure and properties of materials. He is the author of many scientific papers on spectroscopy, electron diffraction, electron microscopy, luminescence and allied subjects. He is the author of a book—"Chemistry of the Defect Solid State" (Methuen, London, 1954). He is a Fellow of the Australian Academy of Science and of the Royal Australian Chemical Institute. He received the Institute's Rennie Memorial Medal in 1945 and its H. G. Smith Memorial Medal in 1951.

Dr. K. L. Sutherland, chief of the new Division of Physical Chemistry, began his research career on the froth flotation of minerals, which was supported by a group of mining companies, in the University of Melbourne. He joined C.S.I.R.O. in 1940 and continued his work on flotation, concentrating particularly on the kinetics of the process. He has gained world-wide recognition for his work in this field. In 1947 he was awarded the Davy Faraday Fellowship of the Royal Institution and worked in London for a period. Later, he was awarded the degrees of D.Sc. of the University of Melbourne and Ph.D. of the University of London. He returned to the Division of Industrial Chemistry in 1950. He recently collaborated with Dr. I. W. Wark in the revision of the second edition of Dr. Wark's book, "Principles of Flotation". He is a Fellow of the Royal Australian Chemical Institute. He received the Institute's Rennie Memorial Medal in 1943 and its H. G. Smith Memorial Medal in 1957. The University of Melbourne awarded him the Grimwade Prize in 1943 and the Syme Prize in 1948.

RURAL RESEARCH

THE lack of agricultural development in the comparatively well-watered section of tropical Australia has long presented an enigma. The region has been either hailed as a land of unlimited potentialities or written off as virtually worthless.

It is only in the post-war period that a systematic effort has been made to define the agricultural and pastoral potentialities of the land and solve the problems limiting its exploitation. Officers of the Division of Land Research and Regional Survey of the Commonwealth Scientific and Industrial Research Organization have been in the forefront of this effort and have shown already that large areas of Northern Australia are capable of agricultural development. By a series of broad-scale land-use potentiality surveys they classified and defined the land. Then Research Stations were established at two type locations to study crop and pasture production. The first of these was for dryland agriculture at Katherine, about two hundred miles south of Darwin, and the second was a joint irrigation venture with the Western Australian Department of Agriculture on the Ord River in the East Kimberleys.

Accounts are given in "Rural Research in C.S.I.R.O." of the successful outcome of research at these stations over the past decade (25, September 1958). Reasons for past failures have been explained, and with the new knowledge, crops such as sugar, rice, cotton and peanuts have been cultivated successfully under experimental conditions. Returns from peanuts as a major cash crop at Katherine and successes with subsidiary crops offer promise for the establishment of profitable mixed farming with associated livestock industries over large areas. At the Kimberley Research Station, sugar has done extremely well under irrigation, while rice, cotton and safflower are very promising. These experimental results must be supplemented by further economic data from farm-scale trials before settlement can be planned.

This information is now being sought as part of a joint venture with the Western Australian Department of Agriculture.

PARAPSYCHOLOGY

THE Institute for the Study of Mental Images was started informally in May 1956 as a private venture "in order to evaluate the status and behaviour of mental images not immediately related to sensory stimuli, and to pursue theoretical investigations in general psychophysical theory". An investigation of hypnagogic images is claimed to be in progress, assisted by a grant from the Parapsychology Foundation, New York. Three communications have now been published*.

In fairness to the authors, it must be made clear at once that their tripartite paper is a serious and learned essay in the philosophy of science—or in scientific philosophy, as it might better be termed in this case. Of its type, it is good. The technicalities are mainly in the language of physics, which most scientific readers will find more to their taste than symbolic logic; the text, though it could be clearer, compares well with that of the majority of disquisitions of this type; and the authors have avoided the more obvious traps. On the other hand, they have had to pay the price of extreme generality, abstraction and impartiality by seeming a little inconclusive.

But let them speak for themselves. The paper attempts "to bridge the considerable gap between psychiatry and advanced physics as the first step towards a psycho-physical theory of the world. A beginning is made by following Sir Arthur Eddington in questioning the usual *separability assumptions* which underlie all scientific investigations". (By "psychiatry" they clearly mean a class of psychological theory, not the day-to-day practice of the art.) Their purpose is "to outline a psycho-physical world theory which is both self-consistent and of sufficient generality to provide a framework for the discussion of all widely held opinions. . . . If this ideal could be realized, men might indeed become as little children, and continue throughout their lives to learn by experience, and to realize their mistakes, without becoming involved in paranoid ideological systems—whether religious, scientific, political or psychoanalytic".

They add, modestly enough, that their theory "has two of the chief characteristics of all paranoid phantasy, i.e., that it is self-consistent and incomplete".

The particular "widely-held opinions" exemplified are, of course, those related to the credibility (in the ordinary sense) of parapsychological phenomena and 'miracles' in general. The central point appears to be that it is illogical to claim that an alleged paranormal phenomenon is impossible by appealing to a scientific argument which rests on an assumption that absolutely precludes the phenomenon; one might as well say simply: "I do not believe it because it contradicts what I *do* believe". The psychiatrist, Dr. Michael Balint, is taken to task for falling into this elementary trap in connexion with the Lourdes 'miracles'. He is quoted as saying, in effect, that the criteria of cure (for example, that it must be instantaneous) are so unrealistic as to force the doctors concerned to distort the facts. It is true that Dr. Balint is out of his depth in these logical waters, or he would have realized that all arbitrary criteria (including that graven image, 'statistical significance') distort facts; but he is a practising clinician, and was clearly, though perhaps unwittingly, giving a clinical opinion rather than a sample of pure reason.

The authors of this paper, on the other hand, instead of taking sides, have attempted to found a system of thought in which it will not be necessary to take sides; in which what we now have to call either supernatural or bogus will be seen as natural. This ambitious project may be attempted in innumerable ways, varying from the easy to the impossible. The easiest way is simply to assert that all things are possible. The respectable empiricist who insists that no duly authenticated observation should be rejected on theoretical grounds evades being charged with this unlimited credulity at the risk of being challenged on his standard of due authentication. It is a weakness of this paper that it does not adequately meet the challenge.

So far as the authors' discursive style reveals, their basic strategy is to invoke the well-known common cause type of theory. Thus, if the universe is a gigantic statistical family tree, significant correlations of some kind should crop up occasionally in card-guessing experiments and the like. The interest lies, not in the general proposition as such, but in how it is handled; here the authors' many well-informed and thought-provoking remarks are marred by a disappointing reluctance to come to the point. W. E. HICK

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* "Introduction to Parapsychology". By C. C. L. Gregory and Anita Kohsen. Communications of the Institute for the Study of Mental Images. Vol. 1, Part 1 (1957); Parts 2 and 3 (1958). (Church Crookham, Hants: Institute for the Study of Mental Images.) 3*s*. each.

GEOLOGY AND PALÆONTOLOGY IN MALAYA

Pre-Tertiary Stratigraphic Succession in Malaya

As a result of progress in geological mapping in Malaya since 1939 it has been possible to clarify and to extend considerably the range of known pre-Tertiary stratigraphic units. Formerly, for lack of sufficient palæontological evidence, the sedimentary formations in Malaya were believed by Scrivenor[1,2] and Willbourn[1] to be limited within the late Palæozoic and early Mesozoic eras to the range Carboniferous–Permian–Triassic, and it was thought that, except in the extreme north-western part of the country where arenaceous rocks had been found to underlie calcareous rocks, the formations older than the granite consisted only of one major sequence of characteristically arenaceous rocks of Triassic age and one major sequence of characteristically calcareous rocks of Carboniferous–Permian age. Although some anomalies were observed they were explained by folding, possible unconformity, or the paucity of fossil species, which are too scanty for precise age determinations.

The fact that fossils were so rare in the stratified rocks made it necessary to use lithological characteristics for mapping over large areas. Certain inconsistencies were examined in greater detail by subsequent workers, including Richardson[3], who in 1939 noted in western Pahang that characteristically arenaceous rocks lay structurally immediately beneath characteristically calcareous rocks of Carboniferous–Permian age; and Fitch[4], who in 1940 noted in eastern Pahang that characteristically argillaceous with some calcareous rocks of Lower Carboniferous age lay structurally immediately beneath unfossiliferous arenaceous rocks of presumed Triassic age. Richardson, Service, and Alexander[5] in 1941 recorded their independent beliefs that in western Pahang the unfossiliferous arenaceous rocks which lay structurally immediately beneath the 'Calcareous Series' of Carboniferous–Permian age should not be regarded as Triassic, even though no fossils had been found to prove otherwise. The evidence then available was summarized[6,7] and subsequent work by Alexander[8] between 1947 and 1951 showed that the characteristics of the ultra-stable heavy mineral assemblages of this unfossiliferous arenaceous sequence of western Pahang were not correlative with those of the fossiliferous Triassic rocks found farther east in central Pahang, and added force to the view that this arenaceous sequence is indeed not younger than Carboniferous in age. The status of the proved stratigraphical succession in Malaya by 1951 was then as compiled in 1954 and published in the "International Stratigraphic Lexicon"[9].

In 1952, the Kelantan (Trengganu) Pahang States border area was allocated for systematic detailed mapping. Later, after studying the geological map of Thailand[10], noting certain trans-border anomalies, and doing some preliminary photogeological work, I prepared the ground during November 1954 at the Bangkok meetings of the Economic Commission for Asia and the Far East Working Party of Senior Geologists for the Geological Map of South-East Asia for a detailed stratigraphic correlation survey in the Malaya–Thailand international border areas. Early in 1955 certain parts of Perlis and Kedah were allocated for systematic detailed geological mapping as part of a co-ordinated programme of re-examination of several inconclusive stratigraphic horizons in Malaya, and in 1955–56 the stratigraphic correlation survey in the international border areas[11] was undertaken by a joint party of geologists from Malaya and Thailand.

The results of the work both in the Langkawi Islands and Perlis, and in Trengganu and Kelantan, have been most gratifying and have shown that the

Table 1. Pre-Tertiary Stratigraphic Successions in Malaya and Thailand

Malaya	Age	Thailand
Not yet proved	Late Cretaceous	Not yet proved
Gagau Formation : a predominantly arenaceous sequence not previously differentiated	Early Cretaceous Late Jurassic	Not differentiated
Not yet proved	Early Jurassic	
Lipis Group : a characteristically argillo–arenaceous sequence, formerly known as the 'Younger Arenaceous Series', including an argillo–calcareous formation of late Triassic age; on the West Coast the group is represented by the Semanggol Formation of middle Triassic Age	Triassic	Khorat Series, including the Kamawkala Limestone of late Triassic age
Raub Group : a characteristically calcareous sequence formerly known as the 'Calcareous Series' (the old 'Raub Series')	Permian Late Carboniferous	Rat Buri Limestone
Bentong Group : a characteristically arenaceous sequence formerly known as the 'Older Arenaceous Series', including lenticular cherty formations towards the base of the succession	Carboniferous	Kanchanaburi Series
Kuantan Group : a characteristically argillaceous sequence, not previously named, including lenticular masses of a calcareous formation high in the succession	Early Carboniferous	
Not yet proved	Devonian	No Devonian proved
Setul Formation : a predominantly calcareous sequence not previously differentiated	Silurian Ordovician	Thung Song Limestone
Machinchang Formation : a predominantly argillo–arenaceous sequence, formerly known as 'C_2 beds' and mapped as Carboniferous	Late Cambrian	Phuket Series
Not yet proved	Early Cambrian	

stratigraphic succession in Malaya does indeed range from at least as early as late Cambrian to as late as early Cretaceous, with very little interruption except possibly in the Devonian and in the Jurassic. The positive identification of Ordovician/Silurian fossils found during the course of the Malaya–Thailand border survey in the predominantly calcareous sequence of the Langkawi Islands[12], together with the evidence of structural alignment of the underlying arenaceous rocks with those carrying late Cambrian fossils on the Thai island of Terutau, were critical factors in establishing the identity of the older rocks in Malaya. Such positive fossil evidence has not yet been obtained for the predominantly arenaceous beds overlying granite found in the Kelantan (Trengganu) Pahang border areas, but is sufficient to indicate for them late Jurassic or early Cretaceous age. In the current research programme is included a project for determining the ages of the various granite masses by isotope ratios of radioactive elements in constituent minerals such as zircon, and it is hoped that the results obtained will establish some correlation with the sedimentary indications already found.

In view of the considerable extension of the proved time-range of the Malayan sedimentary succession I decided early in 1958 to give to the various rock groups and formations in Malaya definite names according to type localities in accordance with the recommendations of the International Geological Congress Sub-Commission for Stratigraphic Terminology. Table 1 summarizes the newly adopted nomenclature and the comparative classification of Palæozoic and Mesozoic stratigraphic sequences now established between Malaya and Thailand[13].

This communication is written as a preliminary announcement to a more detailed paper now being prepared in order to bring up to date the stratigraphic descriptions appearing in the first edition of the section on Malaya in the International Stratigraphic Lexicon. The information in this and the two following communications is published with the authority of the Minister of Natural Resources of the Federation of Malaya.

J. B. ALEXANDER
(Director of Geological Survey,
Federation of Malaya)

P.O. Box 1015,
IPOH, Perak,
Federation of Malaya.
Sept. 30.

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Jurassic/Cretaceous Sediments in Malaya

A FORMATION of gently dipping sedimentary rocks forming the Gunong Gagau plateau was found during a reconnaissance of the Kelantan (Trengganu) Pahang borders in 1952. The succession consists of a coarse basal conglomerate, with cobbles as much as 10 in. in diameter, overlain by a series of progressively finer, interbedded white pebble beds and orthoquartzites, both the latter composed almost entirely of quartz. There are occasional thin red mudstone horizons in which occur plant remains, most of them fragmentary. Recently, better-preserved specimens have been collected which indicate a late Jurassic or early Cretaceous age for the higher part of the formation.

Both in lithology and in the virtual absence of folding and metamorphism these strata appear to be quite unlike any other group of rocks in Malaya, and are the first sedimentary rocks of an age between Trias and Tertiary to have been found. In part they rest with notable unconformity on vertical or steeply dipping interbedded shales, metaquartzites and conglomerates of probable Carboniferous or Permian age. The latter group are characterized by their dark, mainly black, colour arising from the high argillaceous content of the whole succession, and contrast sharply with the light-coloured, overlying beds. Elsewhere, the basal conglomerate overlies granite.

Their discovery throws interesting light on the tectonic history of Malaya. Previously, the folding of sediments and emplacement of granite were thought to be penecontemporaneous and, by analogy with surrounding countries, probably of late Cretaceous or early Tertiary age. However, the present evidence shows that at least a major part of the folding took place early in Jurassic time.

The field-work during the course of which the discoveries were made forms part of the general research programme of the Geological Survey of the Federation of Malaya, and after examination of the area is complete the results will form the subject of a more comprehensive paper.

This preliminary communication is published by permission of the Director of Geological Survey.

J. R. PATON
(Principal Geologist)

Geological Survey,
Federation of Malaya.
Sept. 30.

Graptolites recorded from Malaya

GEOLOGICAL investigations within the past few years in the north-western States of the Federation of Malaya have resulted in the discovery in 1956 of graptolites in shale bands interbedded with limestone of Ordovician/Silurian age[1] which outcrop along the north-eastern shore-line sections of the Langkawi Islands (6° 25′ N.; 99° 55′ E.). The group of islands lies in the northern funnel of the Straits of Malacca between 20 and 30 miles west of the State of Perlis. Graptolites have been found since in shale associated with limestone in the northern end of the Kinta Valley (4° 46′ N.; 101° 06′ E.) of central Perak. Although the graptolites which have been recovered so far are generally of poor preservation they provide sufficient information to date several horizons with considerable accuracy within the period Caradocian–

Llandovery. Previously, for lack of sufficient palæontological evidence, these formations had been ascribed to the Carboniferous period by conservative lithological comparison with fossil-bearing strata on the mainland of Malaya[2].

It is of more than passing interest to note that the nearest locality to Malaya previously known to provide a graptolitic fauna of Llandovery genera is that at Panghsa-pye (22° 42′ N.; 97° 16′ E.) in the Northern Shan States of Burma as recorded by Holland[3], Chhibber[4], and Krishnan and Jacob[3]. In addition, graptolite-bearing beds of Valentian age have been reported by Sondhi[5] at Wapya Taung (20° 53′ N.; 96° 38′ E.) and at Kwawktap (20° 05′ N.; 96° 46′ E.) in the Southern Shan States. These occurrences all lie more than a thousand miles north of the Langkawi Islands, so that the localities in the Federation of Malaya provide a link between Burma and Australia which will undoubtedly be of great value to palæogeographers in the future.

The field-work during the course of which the discoveries in Malaya were made forms part of a co-ordinated programme of re-examination of several inconclusive stratigraphic horizons, and I am indebted to the Director of Geological Survey, Federation of Malaya, for his guidance and permission to publish this communication.

C. R. Jones
(Geologist)

Geological Survey,
Federation of Malaya.
Sept. 30.

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A RAPID MICRO-QUANTITATIVE METHOD FOR ESTIMATING SERUM CALCIUM

By T. A. HARPER

Group Pathology Laboratory, City General Hospital, Sheffield

An accurate micro-method for estimating serum calcium in children and infants is a necessity in many clinical laboratories. Several micro-methods, using dye solutions, were examined in order to select one for use in this laboratory. The criteria laid down for the method to be adopted were: (1) avoidance of calcium precipitation by oxalate, (2) specificity, (3) accuracy, (4) reproducibility, (5) simplicity, (6) use of available apparatus without any modifications, (7) easily available chemicals, (8) reasonable stability of the reagents as stock solutions. Each of the methods examined had some drawback which precluded its adoption as a routine procedure.

However, the method described by Tammelin and Morgensen[1] satisfied the criteria mentioned earlier. In alkaline solutions murexide–ammonium purpurate is specific for calcium. They made use of the reaction in which the colour of a murexide solution changes from purple to pink on the addition of calcium. Their results showed that it was possible to estimate microgram quantities of calcium in water solutions, even in the presence of magnesium, by means of spectrophotometric determination of the calcium murexide complex. Accordingly, the calcium concentration of 315 samples of serum—obtained from blood donors—was determined to find out the normal range for this method. The purpose of this communication is to present the results obtained and to demonstrate a method for correcting the results to agree with oxalate precipitation methods, as the accepted normal range for serum calcium has been determined by these methods.

The following reagents were used: (1) saturated murexide solution is prepared with distilled water and the solution stored, in a brown bottle, in the + 4° C. refrigerator to decrease the rate of decomposition. A fresh solution need only be prepared after 3–4 weeks. A sufficient volume for the number of tests is centrifuged before use. (2) Piperidine. (3) Stock standard calcium (1 mgm. ≡ 1 ml.). 'Analar' grade of calcium carbonate is dried at 105° C. for 24 hr. 2·5 gm. are weighed and transferred to a 1-l. flask. 200 ml. of distilled water and 50 ml. of normal hydrochloric acid are added. When dissolved, water is added to the mark. (4) Working standard calcium (9 mgm. per 100 ml.) prepared from the stock solution. The apparatus used were a 'Unicam' *S.P.* 600 spectrophotometer and auto self-set zero micropipettes.

Three test tubes are labelled *T* (test serum), *S* (standard calcium solution) and *B* (blank). 4·9 ml. of distilled water is added to tubes *T* and *S* and 5 ml. to tube *B*. 0·1 ml. of the test serum is pipetted into *T* and 0·1 ml. of the working standard calcium solution into *S*. Then one drop of piperidine and 0·25 ml. of the saturated murexide solution (centrifuged before use) are added to each of the three tubes and the contents mixed thoroughly. The optical densities of the three solutions are then read in the spectrophotometer at 500 mμ wave-length using the 0·5-cm. cuvettes, the instrument being set at zero with a water blank.

A permanent standard calibration curve is not possible because, on storage, there is a decrease in the optical density of the saturated murexide solution.

By calculation:

$$\text{Serum calcium} = \frac{\text{Reading of (Test Serum–Blank)}}{\text{Reading of (Ca Std.–Blank)}} \times 9\ \text{mgm./100 ml.}$$

Freeze-dried serum, analysed by the Joint Committee of the Association of Clinical Pathologists and the Association of Clinical Biochemists, was obtained from C. David Keeler, Ltd., and reconstituted. The method was carried out on this serum. The corrected calcium concentration of the

Table 1. SERUM CALCIUM RANGE (MGM. PER 100 ML.)

Author	Method	Lower 1 per cent	Lower 10 per cent	Upper 1 per cent	Upper 10 per cent	Average
Smith *et al.* (ref. 3)	Emission spectrograph	6·08	—	—	10·54	8·6
King and Wootton (ref. 4)	Oxalate precipitation and titration with potassium permanganate	9·0	9·6	10·8	11·4	10·0
Elliott and Pearson (ref. 5)	Oxalate precipitation and spectrophotometric determination with excess potassium permanganate	10·6	—	—	14·6	11·8
Tammelin and Morgensen (ref. 1)	Spectrophotometric determination of calcium murexide complex	7·6	8·0	9·8	10·7	8·9

working standard calcium solution was obtained thus:

$$\frac{\text{Reading of (Ca Std.–Blank)}}{\text{Reading of (Serum Std.–Blank)}} \times \text{Ca conc. of Serum Std. mgm. per 100 ml.}$$

The corrected value of the working standard calcium solution is now used instead of the value 9 for the calculation of the calcium concentration of test sera.

The standard serum is used as the control for the method[2].

The normal serum calcium range varies with the technique employed for its determination (Table 1). It has been found that the murexide techniques give lower results than oxalate precipitation methods[6,7]. This was verified in this series. The range quoted by King and Wootton[4] is the accepted one, and, in order to avoid confusion, the results obtained with murexide techniques must be corrected in order to bring them into agreement with oxalate precipitation methods. Eldjarn, Nygaard and Sveinsson[7] found that the best agreement was obtained when their values were multiplied by a factor of 1·046. The method of correction adopted here is considered to be satisfactory because the subsequent results were in close agreement (± 1 per cent) with those obtained when using the oxalate precipitation method described by King and Wootton[4] and also with various batches of standardized sera which were afterwards used as controls.

The method gives accurate and reproducible results (± 1 per cent), for this has been proved when using the various batches of standardized sera. However, the results obtained with simpler instruments will not be as accurate as those obtained with the spectrophotometer. The method was also tested on two other instruments: (1) the 'Spekker' photoelectric absorptiometer using the Ilford spectrum filter blue-green (603), and (2) the Gallenkamp direct-reading photoelectric colorimeter using the Ilford bright spectrum blue-green filter (623); an optical glass block is inserted into the 1-cm. cuvettes in order to obtain mid-scale readings. The errors with these instruments were ± 2 and ± 3 per cent respectively.

I am indebted to Dr. C. C. Bowley and Dr. J. Darnborough of the Sheffield Regional Blood Transfusion Service Laboratories for the generous supply of sera and to Dr. D. W. Auchinachie, principal biochemist of the City General Hospital, Sheffield, for his advice and encouragement.

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EFFECT OF RADIATION ON THE BREAKDOWN OF HOMOGENEOUS FIELD AND SPHERE GAPS

By K. R. ALLEN and DR. K. PHILLIPS

Research Department, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester 17

IN the course of some experiments with homogeneous-field electrodes separated by 1 cm. in nitrogen at atmospheric pressure, to which was applied a positive d.c. voltage of 30 kV., it was found that the rate of breakdown increased when the gap was irradiated. Rogowski and Wallraff[1] found that radiation, which would produce a current of 5×10^{-12} amp./cm.^{2} in a spark gap, would reduce the minimum breakdown voltage by about $\frac{1}{2}$ per cent for a gap of 1·5 cm. between spheres at atmospheric pressure.

A quantitative investigation of this effect has been carried out using homogeneous-field electrodes mounted in a glass chamber. The voltage was obtained from a positive high-voltage d.c. source accurately stabilized and controlled by means of a helical potentiometer. After an initial warm-up period, the drift in voltage was found to be approximately 1 part in 5,000 per hr. A 0·001-microfarad condenser was charged through a 100-MΩ resistor, which was in turn connected to one electrode by a 10-MΩ resistor. This arrangement ensured that, when a spark occurred in the chamber, the voltage was chopped and the condenser had to recharge before another spark could occur. The number of discharges per minute was counted for different values of applied voltage for electrode gaps of 1 and 2 cm. at pressures of 76 cm. and 38·8 cm. of mercury in air. The source of radiation was 0·1 mgm. of radium in a nickel pellet situated at (*a*) 30 cm. from

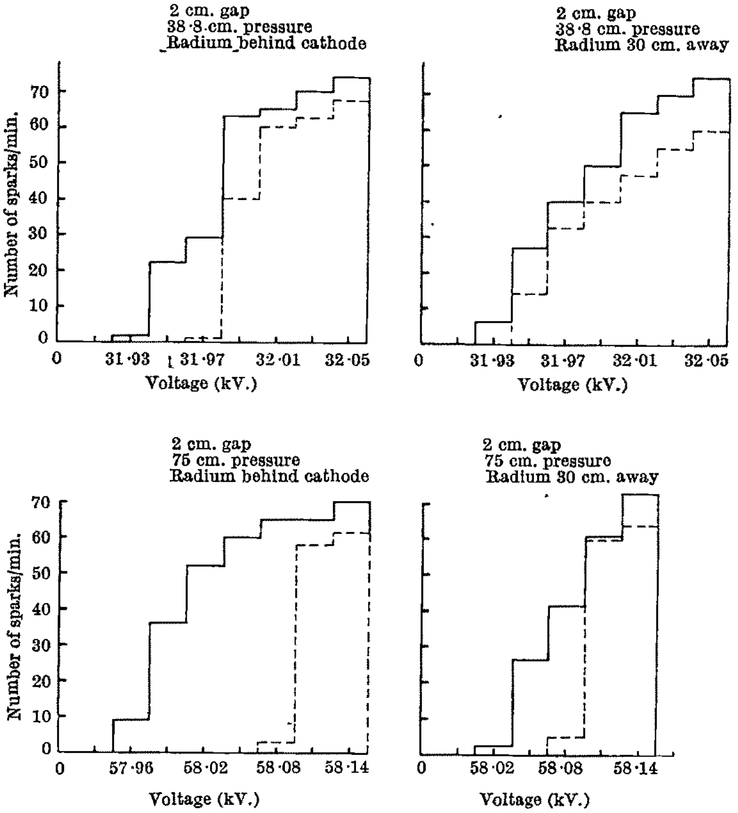

Fig. 1. Histograms showing the variation of the number of sparks/min. with voltage for a 2-cm. homogeneous field gap for different amounts of irradiation and at different air pressures

the gap and (*b*) immediately behind the earth electrode. For each applied voltage, spark counts were taken alternately with and without radiation for 1-min. periods. An example of the results is given in the form of histograms in Fig. 1 for a 2-cm. gap. The dotted histograms give the rate of breakdown without irradiation. In all cases there is an increase in the number of sparks per minute when the gap is irradiated, and there are larger differences between the spark counts as the intensity of irradiation is increased. This increase is more pronounced at atmospheric pressure.

A comparison has also been made between the performance of spheres and plane electrodes, and the results for weak irradiation are shown in Fig. 2. The breakdown voltage of a uniform field gap of 1 cm. was about 2 per cent less than for the same spacing between 5-cm. spheres, and for the experiment the separation of the spheres was reduced to 0·975 cm. so that both gaps broke down at the same voltage. The gaps were connected in parallel and placed so that the radium was 30 cm. from both. The apparent reduction of the breakdown voltage by irradiation was only about 0·1 per cent for the uniform field, but it was about 1 per cent for the spheres. The histogram for the latter also shows that the counting-rate increased relatively slowly with voltage. As a result of this, it is more difficult to determine the minimum breakdown voltage for sphere gaps, and it is necessary to define the intensity of radiation and also the sparking-rate for the minimum breakdown voltage quoted.

The current in the uniform gap when the radium was immediately behind the cathode was about 10^{-11} amp./cm.^{2}, and this would possibly cause some distortion of the field. When the radium was 30 cm. from the gap, the current was several orders of magnitude less, and it seems unlikely that distortion of the field would then occur. The obvious explanation is that irradiation produces more avalanches, resulting in an increased density of positive ions and leading to breakdown when it reaches a critical value. Since the histograms for the irradiated and unirradiated gaps are very similar in shape, it seems reasonable to assume that the breakdown mechanism is the same in both cases, and depends on the successive growth of avalanches across the gap. This is effectively the Townsend mechanism of multiple-avalanche production, but without necessarily having recourse to a γ-mechanism. Evidence in support of this explanation is afforded by observations of avalanche growth in a cloud chamber. Here it was found that 'curtains' of avalanches originated from the ionization produced by an electron track within the gap. If several such curtains are formed in a time less than that required for positive ions to diffuse out of the gap, then the density of positive ions will build up rapidly. The density of positive charge is a significant factor and explains why the irradiation has less effect at lower pressures.

If one considers the field distribution across a sphere gap, the effect on α is to reduce its value in the mid-gap region. Consequently, avalanches beginning to grow from the cathode may not reach the anode if α falls to a low value. On the other hand,

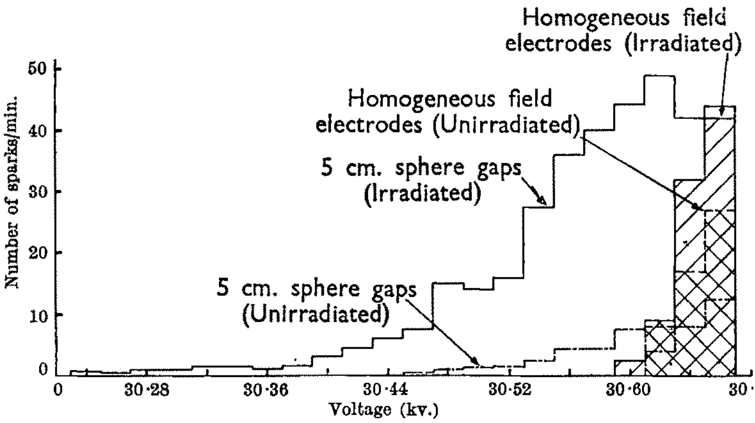

Fig. 2. Comparison between the number of sparks/min. for homogeneous field and sphere gaps of 5 cm. diameter. 1 cm. homogeneous field gap and 0·975 cm. sphere gap. 76 cm. pressure. Radium 30 cm. away.

mid-gap avalanches will grow to the anode in a region of increasing field. If the value of αd is calculated for an avalanche crossing half the non-uniform field gap of 1 cm. between spheres of 5 cm. radius, it is found that the value of X/p required to give equal values of αd is several per cent greater for the spheres. This effect is connected with the phenomenon known as the Toepler[2] discontinuity, and has been studied in detail by Claussnitzer[3].

The relatively slow increase in counting-rate with voltage for sphere gaps can be explained as follows. The value of α across a uniform field is constant, whereas in a sphere gap α has a greater value near the electrodes than in the middle. Therefore, as X/p is reduced in the first case, α rapidly changes from a value which is sufficient to maintain ionization growth to a value which cannot support such growth. In the second case, as X/p is reduced, there is a larger range in which α is sufficient to produce ionization growth. It has been observed that the slope of the counting-rate curve is affected by the presence of water-vapour; results will be reported later. No correction has been made for the effect of humidity, but since the measurements are relative such a correction was considered unnecessary.

The greater effect of irradiation in the case of spheres can be explained as being a volume effect. The average ionization produced by natural causes is about 10 electrons/c.c./sec. In a sphere gap the effective volume for avalanche growth is small; hence any artificial sources of radiation will add to the low value already existing, whereas the uniform field can be assumed to be sufficiently irradiated by natural sources. Here again the fact that α varies across the gap explains why the voltage can be reduced further with irradiation in a sphere gap than in a uniform field. If the voltage is reduced by a small amount and α drops to less than a minimum value, no reasonable amount of irradiation will cause the uniform-field gap to break down.

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HEPARIN AND THROMBOPLASTIN GENERATION IN THE HORSE

By Dr. R. K. ARCHER

Equine Research Station of the Animal Health Trust, Newmarket

AND

P. FLUTE

Department of Medicine, Cambridge

A SERIES of experimental ponies were injected intravenously with 250 I.U. per kilogram of heparin ('Liquemin'; Roche) and a number of observations made on these animals. The horse has at least one appreciable experimental advantage, in that it is possible to remove relatively large volumes of blood at frequent intervals without materially affecting the physiological *status quo*. The purpose of this communication is to enlarge upon a thromboplastin generation defect which was observed.

The expected prolongation of clotting time in glass tubes at 37° C. was accompanied by prolongation of the one-stage plasma prothrombin time, using either horse brain thromboplastin or Russell's viper venom. There was a concurrent defect in thromboplastin generation. With the exception of the test using Russell's viper venom all these abnormalities extended over a period of five hours after the injection (Fig. 1).

Thromboplastin generation tests were performed according to the method of Biggs and Douglas[1], modified by replacing platelets by a chloroform extract of acetone-dried horse brain[2], and using only horse blood in the preparation of the solutions. Alumina plasma was prepared from high-spun citrated plasma with a very low platelet content. A typical series of results is shown in Fig. 2. In the preparation of each curve alumina plasma, serum and substrate plasma were each derived from the appropriate blood specimen. The experiments were performed upon six ponies.

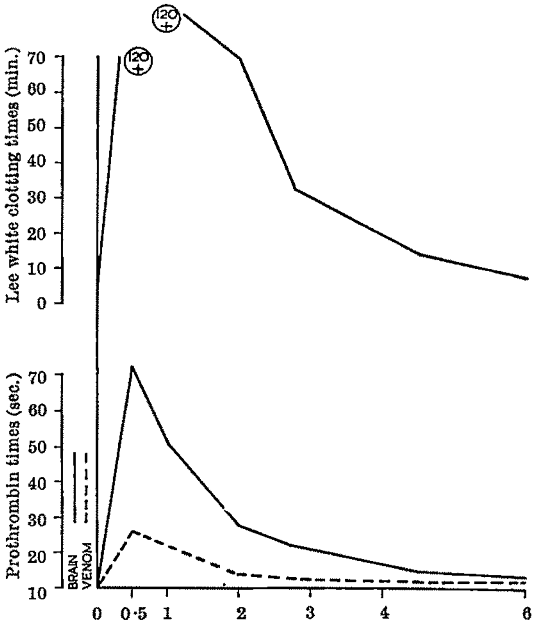

Fig. 1. The effect of intravenous heparin in the horse upon whole blood clotting time; and the 1-stage prothrombin time using either brain extract or Russell's viper venom as the thromboplastic source

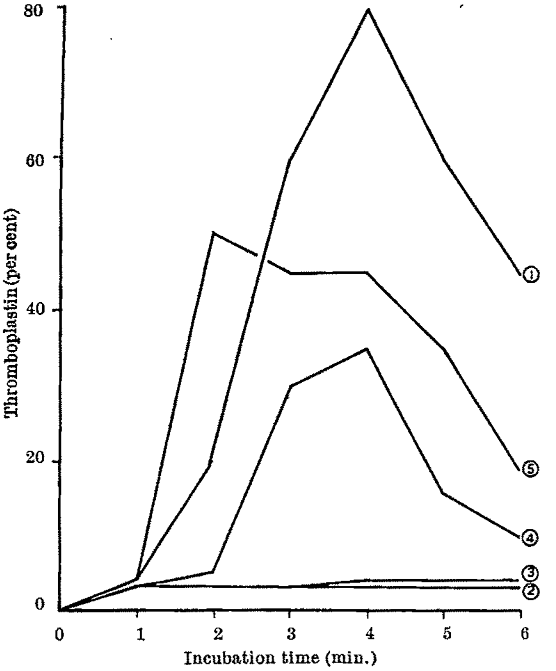

Fig. 2. Thromboplastin generation in the horse after intravenous heparin. (1) Before injection; (2) ½ hr.; (3) 1 hr.; (4) 2 hr.; (5) 4 hr. after injection

It was possible to demonstrate that plasma taken 2 hr. or more after the injection of heparin reacted equally as well as normal horse plasma when used as substrate in the test. The persistent defect in curves 4 and 5 therefore represents a failure of thromboplastin generation rather than a failure to react with formed thromboplastin. Subsequent attempts to define the nature of this defect were confined to specimens taken at 2 hr. or afterwards.

Substitution of either normal alumina plasma or normal serum in a system otherwise derived from the 2-hr. post-injection specimen gave an increase in thromboplastin formation in each case, though this was usually greater when normal serum was used. Thus a defect in both alumina plasma and serum activity was detected.

The addition of 0·1 ml. of saline, or saline containing other reagents at various dilutions, to a system wholly derived from the 2-hr. post-injection specimen was next investigated. Complete correction could not be achieved. Normal horse alumina plasma corrected the deficiency to 60 per cent of normal at an optimal original dilution of 1 : 5; normal serum corrected to 70 per cent at 1 : 10 original dilution; a preparation of Christmas factor from horse serum[3], shown to be as active as normal human serum in replacing the defect in a human subject with severe Christmas disease, gave only 40 per cent correction at a 1 : 20 original dilution. Normal horse serum previously adsorbed with a suspension of aluminium hydroxide gave the best overall correction, usually 80 per cent at a 1 : 10 original dilution.

These results in the horse differ from those reported in humans. Following the injection of heparin into human volunteers, O'Brien[4] has described a deficiency in thromboplastin generation corrected by normal serum but not by Christmas disease serum or by alumina-adsorbed serum. Normal alumina-adsorbed human serum and alumina-adsorbed serum from a case of severe Christmas disease were as effective as horse alumina serum in the correction of the defect in the horse.

Conversely, in one experiment, plasma from the 2- and 4-hr. experiments was equally as active as normal horse plasma in replacing the deficiency in the plasma of a human subject with classical hæmophilia (hæmophilia *A*). The 2-hr. specimen had only 25 per cent, and the 4-hr. 45 per cent, of the ability of normal horse blood to replace the deficiency of a human subject with Christmas disease (hæmophilia *B*).

Using Russell's viper venom as a source of thromboplastin the one-stage times of the 2- and 4-hr. plasma specimens were normal, though the defect seen using horse brain thromboplastin still persisted. This suggests that the latter may be accounted for by a deficiency of factor VII[5].

It has been demonstrated[6-8] that the horse coagulation system resembles that of humans in many respects. Since the defect in thromboplastin generation produced by heparin is corrected by alumina adsorbed serum, a deficiency of factors thought to be present in adsorbed human serum must be considered.

Factor X and Stuart-Prower factor, which may be identical[9], are associated in man with a deficiency of both thromboplastin generation and the one-stage prothrombin time using Russell's viper venom[10]. These may be present in alumina serum, but as the Russell's viper venom time has been shown to be normal while thromboplastin generation remains deficient, they are unlikely to give rise to the defect described here.

Human plasma exposed to contact with glass shows accelerated clot formation[11]. Failure to react normally to contact with glass, together with failure of thromboplastin generation, is seen in humans deficient in either Hageman factor or plasma thromboplastin antecedent[12]. Both these factors are known to be present in alumina-adsorbed serum as well as in serum and in alumina-plasma. Glass contact has been shown to activate factor VII and Christmas factor[13], and human cases deficient in plasma thromboplastin antecedent behave as if they have a deficiency of Christmas factor activity[12].

If a similar reaction to contact with glass, dependent upon factors with similar properties, exists in the horse then the findings after heparin injection might be interpreted as a failure to react normally to contact with glass. Further investigations of the ability of normal horse plasma to react to contact with glass is necessary before these observations can be fully interpreted.

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REDUCTION IN THE LETHAL EFFECTS OF RADIATIONS ON *ESCHERICHIA COLI B* BY TREATMENT WITH CHLORAMPHENICOL

By Dr. N. E. GILLIES and TIKVAH ALPER

Medical Research Council Experimental Radiopathology Research Unit,
Hammersmith Hospital, London, W.12

MANY procedures have been reported for bringing about 'recovery' in *Escherichia coli B* after irradiation. Alper and Gillies[1] found that the observed sensitivity of this strain to both ultra-violet and ionizing radiations was very dependent on methods of culture, and that survival of the irradiated bacteria was least in those conditions in which the non-irradiated bacteria grew fastest. This suggested that inhibition of some metabolic step, for a limited period after irradiation, might lead to increased survival of the irradiated bacteria. Since chloramphenicol has been reported to inhibit protein synthesis[2], its effect on irradiated cells of *E. coli B* has been investigated. It has been found that the lethal effects of both X-rays and ultra-violet light are greatly reduced if the bacteria are incubated for a period after irradiation on solid medium containing chloramphenicol (5 μgm./ml.). We believe that no post-irradiation treatment reported hitherto has been as effective in reducing the observed sensitivity to X-rays.

Survival of the bacteria was determined by counting colonies which grew on 'Cellophane' carriers lying on the surface of nutrient agar ('Oxoid' blood agar base). The use of these carriers throughout the experiments permitted rapid transfer of irradiated or control cells from one medium to another, so that they could be removed from contact with the chloramphenicol without the necessity for washing and centrifuging. The methods of preparing bacterial suspensions for irradiation, and of dispensing aliquots on to the 'Cellophane' carriers, have been previously described[1]. Ultra-violet irradiations were carried out with the bacteria spread on pieces of 'Cellophane' lying on the surface of agar gel containing no nutrients. In the X-ray experiments the bacteria were irradiated in liquid suspension, in the presence and absence of oxygen, by methods which ensured control of the dissolved gases[3]. Transfers to nutrient medium, with or without chloramphenicol, were made as soon as possible after irradiation, and all plates were warmed to 37° before transfer. Colony counts were made after a final incubation period of at least 15 hr. on nutrient medium, and treatments of irradiated bacteria were always matched by the same treatment of controls, which were found to yield a constant count irrespective of the length or timing of the incubation period on chloramphenicol–agar.

The X-ray experiments were carried out on stationary-phase suspensions only. Dependence of the surviving fraction on the period of incubation on chloramphenicol–agar is illustrated by Fig. 1. With no chloramphenicol treatment, a dose of 19 kilorads delivered in anoxic conditions reduced the population to the same fraction as a dose of 9·9 kilorads delivered under oxygenation. It may be seen that the 'rescue' by chloramphenicol treatment was considerably greater after irradiation in anoxic conditions. Incubation for 3 hr. on chloramphenicol–agar immediately after irradiation increased the surviving fraction by a factor which corresponded to a twofold reduction in the effectiveness of the X-rays delivered in the presence of oxygen, and a fourfold reduction in anoxic conditions. The factor by which oxygen was observed to enhance the effect of radiation was only about two, if surviving fractions were compared when the bacteria were placed immediately on nutrient agar. This ratio was roughly doubled, however, if the observations were made on surviving fractions after 3 hr. of chloramphenicol treat-

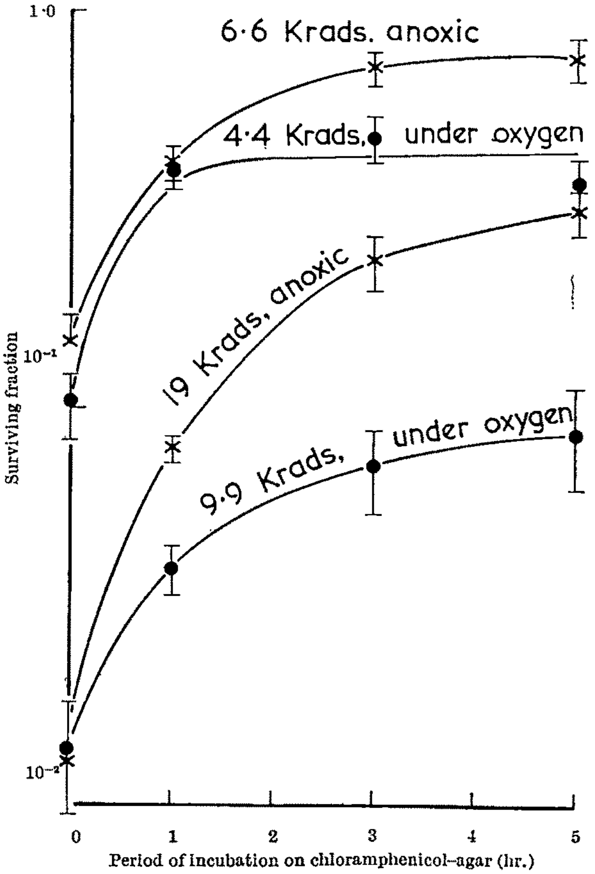

Fig. 1. Dependence of surviving fraction of X-irradiated *E. coli B* (stationary phase) on period of incubation on chloramphenicol–agar

ment. These results confirm our previous report[4] that the enhancing action of oxygen is exerted mainly on a fraction of the damage not affected by post-irradiation conditions. When these are of a nature to reduce overall sensitivity, the observed effect of oxygen is increased.

The dependence of surviving fraction on the period of incubation on chloramphenicol-agar, after ultra-violet irradiation at 2537 A., followed roughly the same course as that illustrated in Fig. 1, when stationary phase bacteria were used. An interesting difference was observed, however, when bacteria in the logarithmic phase were exposed to ultra-violet light. As shown in Fig. 2, short periods on chloramphenicol led to a decrease in the number of colonies formed by bacteria irradiated in the logarithmic phase. This suggests that the initial inhibitory action of chloramphenicol enhances the effect of the radiation, and that a secondary, and more complete, inhibition of metabolism enables many of the cells to proceed successfully to division, after they have been removed from the chloramphenicol.

Survival of both ultra-violet- and X-irradiated bacteria could be still further increased if the irradiation was followed by a preliminary period (up to 1 hr.) on nutrient agar, before commencement of the chloramphenicol treatment. This was found to eliminate the initial decrease in surviving fraction observed with logarithmic phase bacteria. The effects of preliminary incubation on nutrient agar combined with varying periods of chloramphenicol treatment are illustrated in Fig. 3. It can be seen that after a dose of ultra-violet light which reduced the surviving fraction of untreated bacteria to 8×10^{-3}, samples which were incubated for 1 hr. on nutrient agar, then for 2 hr. on the medium containing chloramphenicol, and finally overnight on nutrient medium, formed as many colonies as the control unirradiated suspension. Thus virtually all the effect of this dose of ultra-violet light appears to be due to a metabolic disturbance, the effects of which may be counteracted by the inhibitory action of the chloramphenicol. When stationary-phase bacteria were used, chloramphenicol treatment applied in the same way increased the surviving fraction from 4×10^{-3} to 0·85. In a comparable experiment with X-rays delivered in anoxic conditions, the surviving fraction increased from $7{\cdot}3 \times 10^{-3}$, for bacteria plated on nutrient agar, to about 0·55, after chloramphenicol treatment following 1 hr. preliminary incubation on nutrient medium. Thus a smaller fraction of the overall effect of X-rays is attributable to the metabolic disturbance which is mainly responsible for the lethal effect of ultra-violet light on *E. coli B*.

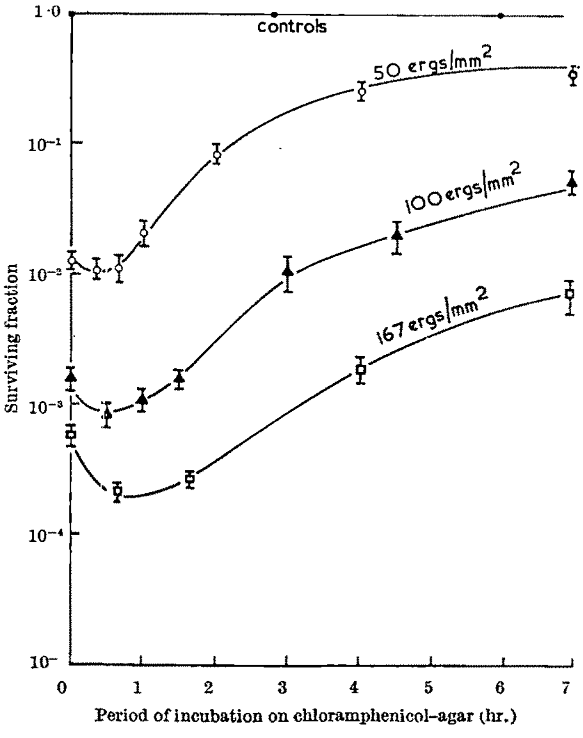

Fig. 2. Dependence of surviving fraction of ultra-violet-irradiated *E. coli B* (logarithmic phase) on period of incubation on chloramphenicol-agar

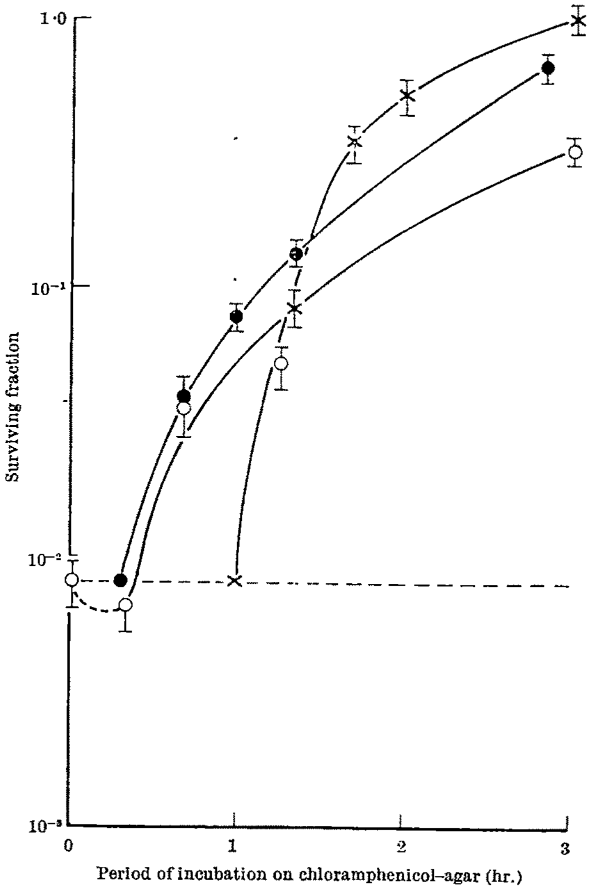

Fig. 3. Dependence of surviving fraction of ultra-violet-irradiated *E. coli B* (50 ergs/mm.², logarithmic phase) on period of incubation on chloramphenicol-agar

○, on chloramphenicol-agar immediately after irradiation; ●, on nutrient agar for 20 min. after irradiation; ×, on nutrient agar for 1 hr. after irradiation

We wish to record our appreciation of the assistance given by Miss Brenda Hodgkins with these experiments.

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LETTERS TO THE EDITORS

ASTRONOMY and ASTROPHYSICS

Volcanoes on the Moon

For some time, opinion on the origin of the Moon's craters has been hardening in favour of the meteoric theory and against the volcanic. The recent observation of volcanic activity by Dr. Kozyrev has, in some quarters, produced a reaction in favour of the volcanic origin. I would like to suggest that this reaction is unnecessary.

Whatever is the origin of the craters it is possible that they may be filled with dust to considerable depths. The thermal conductivity of dust, in a good vacuum, and under a low gravitational pull, is likely to be extremely low, owing to the small areas of actual contact between the particles. It may be supposed that this area of true contact between adjacent particles depends only on the force between the two particles and on the yield-strength of the material composing them. In a thick layer of dust, the force between particles of given size will increase linearly with depth from the surface and hence so will the area of true contact. Suppose the mean density is ρ gm. cm.$^{-3}$. Then at depth h cm. the pressure is ρgh dynes/sq.cm. If the compressive yield-strength of the material is s dynes/sq.cm., the contact-areas in each column of particles will be only $\rho gh/s$ of the cross-sectional area of the column.

The effect of this on the conductivity will depend on the shapes of the particles before deformation. If we use the drastic simplification of supposing the particle contacts to be derived from pyramidal points crushed on to plane surfaces, we find that the effective conductivity k_e is given approximately by $2k\sqrt{\rho gh/s}$ when the quantity $\rho gh/s$ is small, k being the thermal conductivity of the solid material. If we suppose the material forming the dust to be a fairly hard rock (Mohs' scale 6 or Vickers' hardness 700 kgm./mm.^{2}) with thermal conductivity 5×10^{-3} cal. cm.$^{-1}$ deg. C.$^{-1}$, and take g to be 160 cm. sec.$^{-2}$, this gives a value of k_e of about $7 \times 10^{-7}\sqrt{h}$. At 100 m. in the case considered, the conductivity might be around 1/70 of the bulk value or, at 1 m., 1/700 of the bulk value. Owing to the multiplicity of reflecting surfaces, the contribution of radiation can be neglected, and gas conduction, important in more familiar circumstances, is zero.

In such conditions the importance of the Moon's natural radioactivity may be high, although, owing to the Moon's small size, it has usually been thought less important than that of the Earth. Suppose that this is equivalent to 2 parts per million of uranium—appreciably less than the equivalent total activity of the Earth's crust. An isolated piece of such material will then show a temperature rise in the region of 8 deg. C. per million years. Since the conductivity of hot rock is fairly high, the interior of the Moon is likely to have reached an equilibrium temperature some time ago. In equilibrium conditions the heat flux reaching the surface must be the whole of that produced in the interior. This will give about 260 calories per year per cm.^{2} or $8{\cdot}4 \times 10^{-6}$ cal./sec./cm.^{2}. Then if T is the difference between the temperature at depth h and the mean surface temperature:

$$\delta T = \frac{8{\cdot}4 \times 10^{-6}\ \delta h}{7 \times 10^{-7}\sqrt{h}} \text{ deg. C.}$$

$$\text{so } T = 24\sqrt{h} \text{ deg. C.}$$

At 1-m. depth this is already 240° C. It will reach the softening point of, for example, basalt at about 25 m. depth if we neglect changes in properties with temperature. In other words, dust could not lie indefinitely over large areas to depths of more than about 25 m. With a thickness of only a few metres, conduction to the sides of a crater kilometres across will be as important as conduction through the dust. Even if the craters were not formed by volcanic action, however, the mere filling of the larger ones with dust would provide, in time, for volcanic activity in the centres.

It is unlikely that enough material would be involved in any one eruption to cause the ejection of major quantities of liquid or solid. The very low mechanical pressure of the dust would seem rather to encourage frequent small local instabilities due to high-temperature release of gases. These instabilities would result in periodic liberation of puffs of hot gas and dust just as the slow liberation of marsh gas leads to occasional bursts of mud and gas from the bottom of a stagnant pond. 'Frequent' here means many times per million years. The phenomenon would therefore appear analogous to boiling with bumping rather than to volcanic action on the Earth's surface, and would produce just the kind of phenomenon which has been observed. It is not so likely that it could be responsible for the central peaks which are often observed in the larger craters.

I am indebted to Mr. F. R. Stewart of this Department for pointing out that, if this picture of events is even approximately true, a large and fairly accessible source of power should be available to the establishments which will doubtless be set up on the Moon in due course.

J. H. Fremlin

Department of Physics,
University of Birmingham.
Dec. 30.

Changes in the Inclination of Satellite Orbits to the Equator

In a recent article[1], we gave some details of changes in the orbital inclination of *Sputnik* 2 (1957β) and suggested that these changes might be caused by the rotation of the atmosphere. Bosanquet has presented an analysis[2] which supports this view, giving fair agreement with the observed changes. We have now completed a more thorough investigation, taking into account the spread of atmospheric resistance around perigee.

If the atmosphere is assumed to rotate with the same angular velocity as the Earth, and the drag force acts along the direction of motion of the satellite relative to the air, the change, Δi, in orbital inclination i is given by:

$$\Delta i = \Delta T \cdot \frac{\sin i}{6} \cdot \frac{(2I_2 - 4e\,I_1)\cos^2\omega + I_0 - I_2 + 0(e^2)}{(1 - T\cos i)\,I_0 + 2e\,I_1} \quad (1)$$

where T is the period of revolution expressed as a fraction of a day, e is the eccentricity of the orbit, ω is the argument of perigee, I_n is the Bessel function of the first kind and imaginary argument of order n and of argument ae/H, where a is the semi-major axis of the orbit and H is the scale-height of the atmosphere.

It will be noted that Δi is related directly to changes in period ΔT, so that irregularities in air density do not affect the analysis. Also, with $0 < i < 180°$, the inclination i always decreases, so that for a satellite moving from west to east $(0 < i < 90°)$ the maximum latitude decreases—this corresponds to the condition for all satellites launched to date—whereas for a satellite moving from east to west $(90° < i < 180°)$ the maximum latitude increases.

If the Bessel functions are replaced by their asymptotic expansions, equation (1) reduces to:

$$\Delta i = \Delta T \cdot \frac{\sin i}{3} \frac{(1 - 15k/8 - 2e)\ \cos^2\omega + k}{(1 - T\cos i)\,(1 + k/8) + 2e} \times \{1 + 0\,(k^2, e^2\}, \ldots \quad (2)$$

where $k = H/ae$. This expansion is most appropriate, since k and e are of the same order if $0{\cdot}05 < e < 0{\cdot}15$.

Equation (2) shows that the change in i depends mainly on three quantities: (1) i itself—the greater the inclination the greater is the change, because the force due to the rotating atmosphere is more nearly perpendicular to the path; (2) the change in period, ΔT, which is a measure of how much the atmosphere is affecting the orbit in general; (3) the angle ω from equator to perigee, the effect being greatest when perigee is at the equator, where the rotational speed is greatest.

If, in equation (2), the terms in k, e, T are ignored, the equation given by Bosanquet[2] is obtained. For *Sputnik* 2 it is found that the change in inclination obtained from (2) is about 30 per cent less than that given by the simpler equation, and this scarcely justifies the use of the latter.

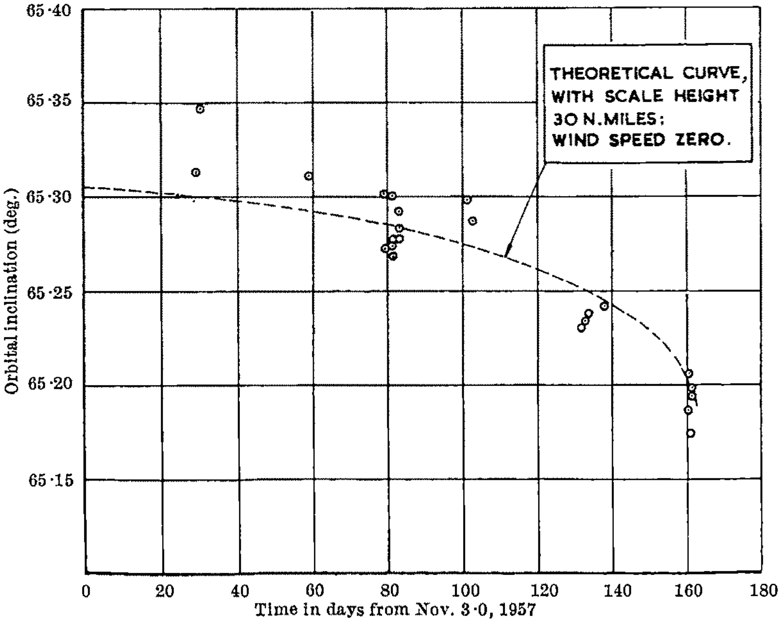

Fig. 1. Mean orbital inclination of *Sputnik* 2 (1957β)

The theoretical curve for the inclination of *Sputnik* 2, obtained by numerical integration of equation (1), is compared with the observed values in Fig. 1. It appears that the theoretical curve is not quite steep enough. Analysis of observations of the rocket of *Sputnik* 3 (1958δ1) is not yet complete, but a decrease in inclination is apparent, and again the theoretical curve is not steep enough. Its slope would, however, be increased if there were a strong wind from west to east. It is indeed possible, in principle, to determine mean wind speed at height of perigee by measuring the changes in orbital inclination; but this would require more accurate observations than are at present available and a theory which took account of other effects such as the oblateness of the atmosphere. The most that can be said now is that rotation of the atmosphere is responsible for the major part of the observed effect.

R. H. MERSON
D. G. KING-HELE
R. N. A. PLIMMER

Royal Aircraft Establishment,
Farnborough, Hants.
Dec. 19.

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'Turbulence' and the Photospheric Granulation

EARLY high-resolution photographs of the solar photosphere showed a well-defined pattern of bright granules with diameters lying mostly in the range 1–2 sec. of arc. The similarity of this structure to laboratory convection patterns led to the view that the granules represent convective cells of the Bénard type. However, although some modern observers[1–3] apparently confirmed the existence of a granular structure with the same narrow distribution of sizes, others reached contrary conclusions. In particular, on the basis of photometric measurements of photographs obtained at Mt. Wilson, some workers[4–6] have concluded that the solar surface actually presents the appearance of random brightness fluctuations. These brightness fluctuations have been identified with so-called 'turbulent eddies'. In fact, the view is now widely held that the photosphere is in a state of aerodynamic turbulence. (This conclusion has been opposed by Plaskett[7].) This interpretation, however, does not accord with results derived from sequences of high-quality photographs of the granulation obtained recently by Leighton[8] in the United States and by us[9] in Australia. These cinematographic observations strongly support the convective interpretation and argue against the existence of turbulence.

Both sets of observations show the granules as bright features of various shapes, 1–2 sec. of arc in diameter, which are separated by darker material. The appearance of individual granules persists in detail from photograph to photograph over periods of several minutes. A photograph of superb quality recently published by Rogerson[10] shows a similar pattern: although there are a few features of diameter less than 0·5 sec., the majority of the granules appear to have diameters in the range 1–2 sec. (The dark boundaries appear narrower than on photographs of lesser quality.) These photographs all strongly suggest that the granules are to be identified with convection cells and not with the 'eddies' of any large-scale turbulence.

In addition, the Australian observations support Leighton's hypothesis that the motions within the granules themselves are non-turbulent. The observations are of sufficient quality to enable the development of individual granules (classified according to brightness, size, and shape) to be followed from photograph to photograph over an average period of nearly 7 min. The 125 granules selected for study displayed remarkable stability: 57 per cent showed no detectable change in brightness, size, or shape over this period, an additional 14 per cent showing only minor changes of shape. This stability argues strongly against the existence of aerodynamic turbulence within the granules. The observations are based on photographs contained in a 10-min. sequence, the variable quality of which limited the period over which it was possible to study changes[9]. A longer sequence of better photographs might well show that the stability persists over even longer periods.

Many workers have deduced the existence of 'turbulent' velocities of the order of 2–3 km./sec. from measurements of line profiles and equivalent widths (cf. Waddell[11]). However, these velocities should be regarded as mere parameters indicating the existence of non-thermal motions[12]: they provide no evidence for fully developed turbulence in the strict aerodynamic sense[13]. Moreover, spectroscopic measurements refer to a region of the photosphere lying above the granulation observed in white light; in this region the vertical convection currents may be modified by the onset of radiative cooling (cf. Plaskett[14]).

The available observational evidence thus argues against the existence of turbulence in the photosphere. How far is this conclusion consistent with the known properties of turbulence in gases? It has often been contended that, in view of the high value of the Reynolds number, the solar gases must be turbulent. However, the Reynolds number criterion for the onset of turbulence is an empirical rule, valid in the case of the forced flow of an incompressible fluid through a pipe, but not necessarily applicable to the photosphere. Moreover, turbulence requires for its maintenance a continuous source of mechanical energy[15,16]. In the photosphere the only possible source is the convective motion, which arises from thermal instability. However, if turbulence were present, the consequent transfer of momentum between the upward- and downward-moving columns would tend to destroy the motion, so that the turbulence would be self-damping.

Richardson and Schwarzschild[17], by an erroneous application of Kolmogoroff's law, have even gone to the extent of deriving a complete 'spectrum of turbulence' for the photosphere (cf. Burgers and Thomas[18]). According to Richardson and Schwarzschild the most energetic 'turbulent elements' have a diameter of about150 km. (ref. 17) or 300 km. (ref. 19) (0·2 or 0·4 sec. of arc); these are identified by them with small, very bright granules—so far unobserved. Our observations are not capable of showing structures as small as this. However, they reveal no correlation between the brightness and size of individual granules: in fact, it is found that bright granules are just as likely to be larger as smaller than average.

R. E. Loughhead
R. J. Bray

Division of Physics,
Commonwealth Scientific and
Industrial Research Organization,
University Grounds,
Sydney.
Dec. 4.

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PHYSICAL SCIENCES

Emission of Slow Secondary Electrons

In a recent paper[1] measurements of the probabilities of multiple emissions of secondary electrons are reported. These indicate that emission of at least some secondary electrons depends on interaction between the primary electron and the solid plasma as a whole, the co-operative interaction[2] as opposed to the individual interaction of current theories[3].

The main points to be explained are: (1) the existence of a group of slow secondaries in a continuous energy-range about 1 eV., nearly independent of the material and of bombardment conditions; (2) the emission of secondaries within 2×10^{-10} sec. following the primary impact[4]; (3) the steep rise of the secondary emission coefficient to a maximum at a primary energy of about 200 eV. followed by a slow fall as primary energy is increased[5]. These facts are consistent with a process for which the classical analogue is the fall of a drop into a body of liquid. As is well known, the reaction of the liquid forces a globule on a narrow neck well above the free surface of the liquid.

In secondary emission, injection of a primary across the boundary will result in transient motions of the negative charge cloud such that a high local negative charge density forms about the point of entry after a time of the order of the period of the plasma oscillation (about 10^{-15} sec.). The rise of this density forces electrons successively over the work-function barrier and accelerates them only slightly after ejection. Such secondaries will be instantaneous to a degree beyond experimental requirements, nearly independent of the detailed properties of the primary, of low emission velocity since acceleration after emission is due at most to a few electron charges. Emission energies will cover a continuous range since acceleration will depend on the rate of build-up of surface charge after ejection, that is, on the phase of the plasma cycle at ejection.

At low primary velocities little energy will be transferred to the plasma since the charge cloud can adjust itself to equilibrium with the moving charge at all stages. Maximum energy will be transferred when the primary electron travels one interaction distance within the plasma in a time of the order of the plasma cycle. Above this velocity energy transfer will fall slowly. Quantum mechanical description of the process is likely to be difficult.

J. M. ANDERSON

Department of Physics,
University of Toronto,
Toronto 5.
Nov. 28.

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Changes in Transition Probability due to the Interaction of Rotation and Vibration in Diatomic Band Spectra

THE distributions of rotational and vibrational intensities in band spectra are frequently used for measurement of effective temperatures in, for example, flames[1] and stellar spectra. In such calculations it has become customary to treat independently the derivation of rotational and vibrational transition probabilities, although the possibility of error has been noted[2,3]. Major errors attributed to an interaction occur with the weak (0, 1) band of OH at 3428 A. as shown by the incompatible rotational 'temperatures' obtained from a plot such as Fig. 1, calculated on the assumption that only rotational transition probability affects intensity within a band. The gradients of the three straight lines correspond to temperatures of 2,290, 1,420 and 750° K. for R, Q and P_1 branches respectively. The curved portions at low energies are due to unresolved satellite branches. Similar treatment of a stoichiometric flame, using the intensities of Bass and Broida[4], give for the (0,1) band R branches a temperature of 4,180° K., and for the P branches 1,380° K.; even the S branch of the (0,0) band at 3064 A. gives 3,560° K. The estimated temperature of the flame was 2,750° K. Further discrepancies for other bands of the system have been reported[5]. The (0,1) band is very weak, and these effects cannot be attributed to self-absorption.

Rotational transition probabilities are derived from statistical considerations. Vibrational ones are based on the Franck–Condon principle and are derived by calculating the overlap integrals of the vibrational wave-functions; they thus depend on the forms of the two potential energy-curves. When rotation is taken into account the potential curves are modified by adding a term in $J(J + 1)/r^2$. Fig. 2 shows curves for the rotational levels $J = 1\frac{1}{2}$ and $J = 20\frac{1}{2}$, and it is seen that the minima are displaced to larger internuclear distances, especially for the upper, $^2\Sigma^+$, state. This displacement modifies the overlap integrals.

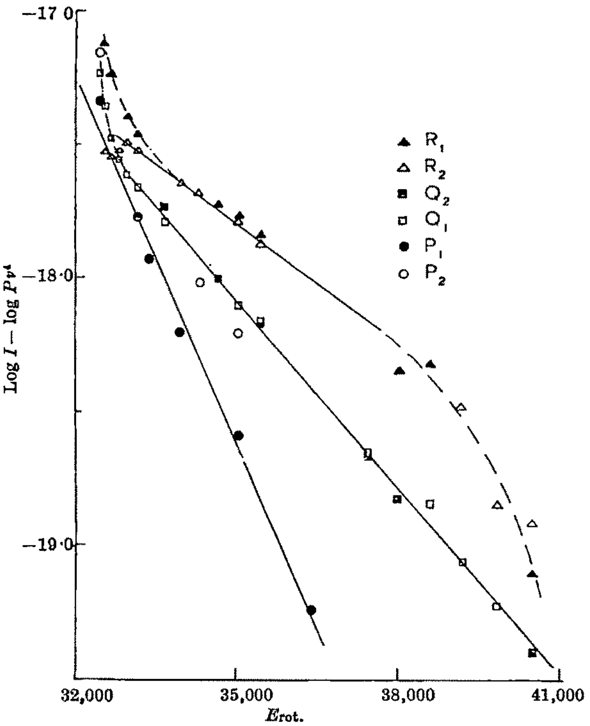

Fig. 1. The (0,1) band of OH at 3428 A. Log $I/P\nu^4$ plotted against the energy of the rotational level from which a transition, intensity I, frequency ν, originated. Source: a hydrogen-rich H_2/O_2 flame at atmospheric pressure, photographed on a large quartz spectrograph of dispersion 4 A. per mm.

We have made calculations of these overlap integrals using wave functions for a Morse–Pekeris oscillator, including rotation[6], and obtain the following transition probabilities:

(0,0) band	P_1 (1)	1·00	P_1 (20)	0·96
	Q_1 (1)	1·00	Q_1 (20)	0·94
	R_1 (1)	1·00	R_1 (20)	0·91
(0,1) band	P_1 (1)	0·11	P_1 (20)	0·12
	Q_1 (1)	0·11	Q_1 (20)	0·15
	R_1 (1)	0·11	R_1 (20)	0·17

Assuming[7] that the electronic transition moment is proportional to e^{-3r} these become:

(0,0) band	P_1 (1)	1·01	P_1 (20)	0·74
	Q_1 (1)	1·00	Q_1 (20)	0·71
	R_1 (1)	0·99	R_1 (20)	0·67
(0,1) band	P_1 (1)	$0{\cdot}01_6$	P_1 (20)	$0{\cdot}01_5$
	Q_1 (1)	$0{\cdot}01_7$	Q_1 (20)	$0{\cdot}02_3$
	R_1 (1)	$0{\cdot}01_8$	R_1 (20)	$0{\cdot}03_5$

It will be seen that for the (0,0) band the changes of vibrational transition with rotational quantum number or branch type are relatively small but, assuming a linear relationship, the change of slope would still cause a difference in temperature of 300° at 3,000° K. For cases such as the (0,1) band where the overlap integral is very small the effect of rotation and of branch type becomes really important.

The results for the (0,1) band are extremely sensitive to the difference $(r_e' - r_e'')$, a change of 0·1 per cent in either r_e causing a change of 10 per cent in the transition probability; the accuracy is

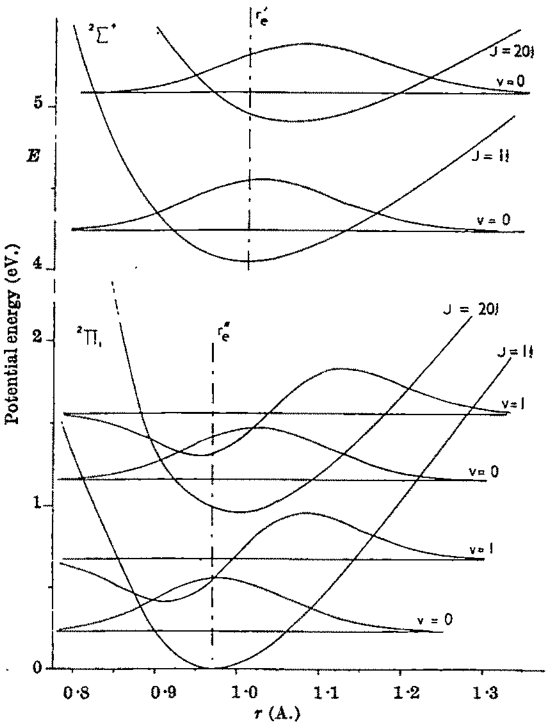

Fig. 2. Graphs of potential functions and wave functions for $A^2\Sigma$ and $X^2\Pi$ of OH

further limited by the result appearing as the difference between two relatively large quantities. The (0,0) band does not suffer from either of these defects and is therefore considerably more accurate.

We are indebted to Dr. R. C. Herman for helpful discussion.

We intend to investigate this problem in greater detail in the near future, using electronic computation to carry out the large quantities of arithmetic involved.

R. C. M. Learner
A. G. Gaydon

Department of Chemical Engineering,
Imperial College of Science and
Technology,
London, S.W.7.
Dec. 12.

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Hollow-Cathode Emission of the AlO Spectrum

All emission bands previously attributed to the AlO molecule have been observed in the glow from a hollow cathode containing $Al–Al_2O_3$ pellets. The hollow cathode is a much more appropriate source for high-resolution studies than is the aluminium arc, and it is therefore gratifying that it may be used to excite materials as refractory as this one. Our discharge tube is quite similar to that described by Naudé and Hugo[1] except that currents as high as 2 amp. were used. It has been employed with a 150,000-line Bausch and Lomb plane grating to record the green (A—X) bands of AlO in third order at a dispersion of 0·4 A./mm. and the ultra-violet bands in second and third orders. Effective resolving powers up to 200,000 have been achieved.

Fig. 1 shows a section of the (0—0) band of the A—X system, near the head. The doublet splitting in the P-branch has been resolved down to $K = 7$. This may be compared to resolution down to about $K = 22$ in high-dispersion studies using the aluminium arc[2–4]. The averages of all measured doublet components agree with the measurements of Pomeroy[2], so that the only unique part of the present analysis of this band is the determination of the spin-doubling constants from lines of low K-values. Since there has been some disagreement about these constants, we here compare our results with those of Lagerqvist, Nilsson and Barrow[3], and of Sen[4], which are based on lines of high K-values :

	This work	Ref. 3	Ref. 4
γ'	0·019 ± 0·005 cm.⁻¹	0·021 ± 0·005 cm.⁻¹	0·030 cm.⁻¹
γ''	0·008 ± 0·006	0·010 ± 0·005	0·021

Fig. 2 shows a section of the more complex ultra-violet system near 3000 A. for which the hollow-cathode exposure times are about five times those for the green bands and for which only a tentative vibrational analysis has been available[5]. The present work shows that each band consists of two sub-bands, each of which contains two strong branches. Further vibrational and rotational analysis proves that the lower-state constants are those of the $^2\Sigma^+$ ground-state, observed also in the green bands. However, the upper-state $(^2\Pi_i)$ vibrational constants are (in cm.⁻¹) :

$$T_e = 33{,}174{\cdot}6, \quad \omega_e = 728{\cdot}4, \quad \omega_e x_e = 7{\cdot}5$$

rather than the following values taken from ref. 5:

$$\nu_{00} = 33{,}085, \quad \omega_0 = 845, \quad \omega_0 x_0 = 4$$

From rotational analysis of the (4—2), (1—0), (0—0) and (0—1) bands the following constants of the $B^2\Pi$ state have been obtained :

$$B_e = 0{\cdot}6027 \text{ cm.}^{-1}, \; \alpha_e = 0{\cdot}0036 \text{ cm.}^{-1} \text{ and } A_1 = -75{\cdot}78 \text{ cm.}^{-1}.$$

The observed Λ-doubling shows that the Π-state is inverted.

Continuous radiation from the cathode has hindered attempts to record the $B^2\Pi_i - A^2\Sigma^+$ bands expected at 8000 A. Earlier (Innes, K. K., and Innes, R. H. C., unpublished work), by means of a 2·5-kV.amp. arc between aluminium electrodes, these 'red' bands of AlO had been observed between 7900 A. and 8700 A. using exposure times about twenty times those necessary for the green bands from the same source. The red bands were complex and the lines were quite broad, due to the hot, comparatively high-pressure, source. Some of the few, irregularly spaced heads were degraded to the red while others were degraded to the violet. The B-value given above for the B-state is nearly equal to that of the A-state and this accounts, qualitatively, for the observed structure of the red bands, including the distribution of intensity and the paucity of sharp heads. The latter feature is probably responsible for the failure of previous attempts to identify the B—A bands at low dispersion[5,6].

The detailed work on the red bands has been resumed to determine if they can add to the information about the $B\Pi_i$ state which has been obtained from the ultra-violet bands. Detailed analysis of the

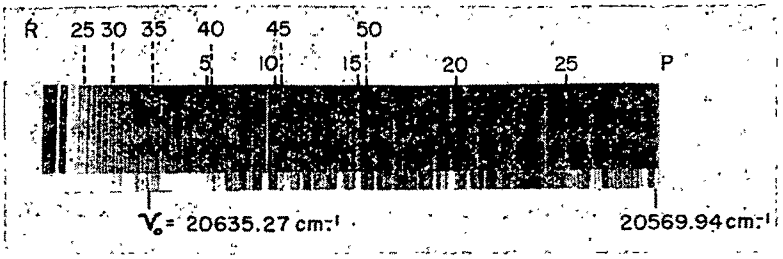

Fig. 1. 0—0 band of the $A^2\Sigma$ -- $X^2\Sigma$ system of AlO (4842 A.)

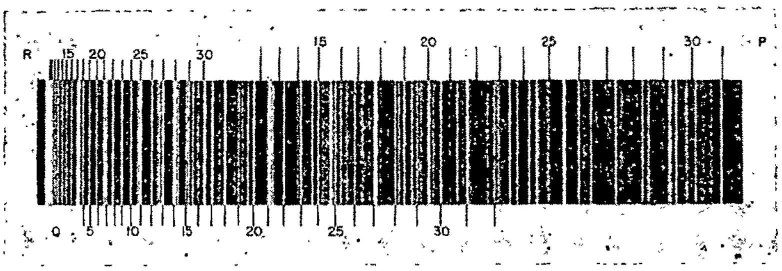

Fig. 2. 0—0 band of the $B^2\Pi_{3/2}$ -- $X^2\Sigma$ system of AlO (3028 A.)

only strong band of the remaining ultra-violet system of AlO is also in progress. A complete report of this work will be published in due course.

Support by the Naval Ordnance Laboratory of White Oak, Maryland, and by the Research Corporation is gratefully acknowledged. We are indebted to Mr. J. U. Upton of White Oak for construction of the discharge tubes used in this work. One of us (K. K. I.) wishes to thank Dr. D. V. Sickman of White Oak for helpful discussions.

V. Wilson Goodlett*
K. Keith Innes

Department of Chemistry,
Vanderbilt University,
Nashville, Tennessee.
Dec. 1.

* United States Steel Foundation Fellow.

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Atomic Electron Affinities

ELECTRON affinities of negative atomic ions are now being measured with increased accuracy[1]. The improvement of the experimental results makes a satisfactory theoretical approach to the problem more imperative than ever.

The best available computations of wide applicability are based on the semi-empirical method of extrapolation. This includes the oldest and most commonly employed method of quadratic extrapolation of ionization potentials first suggested by Glockler[2]. This method, *a priori*, should give the electron affinities correct in absolute value; however, many attempts over a period of years failed to produce satisfactory results. The predictions of the quadratic extrapolation are on average 0·5 eV. too low, and when this amount is added to the computed data the results still have an average error of about 0·3 eV. when compared with the best experiments available to-day. This is evident[3] from columns (1) and (2) of Table 1.

It is our feeling that the reason for the failure of the quadratic extrapolation (and related methods) lies in the sensitivity of the method to the underlying extrapolation formula. For this reason it is essential that such a formula be based on physical arguments and justification. A purely mathematical extrapolation of a table of ionization potentials has no chance of success, because the experimental data which are extrapolated here are insufficient in number as well as in accuracy. This experimental situation cannot be expected to improve greatly within the foreseeable future.

We suggest, therefore, a new extrapolation formula which has physical justification and which involves at least two parameters that admit checks by independent methods. We propose that the ionization potential be written in the form:

$$I(Z) = \alpha(Z - \sigma)^2 + \gamma + \frac{a_1}{Z - \sigma} + \frac{a_2}{(Z - \sigma)^2} + R$$

The quantity R is the remainder of the expansion in inverse powers of $(Z - \sigma)$. The corresponding series for $I(Z)$ can be justified as a fairly fast converging perturbation expansion. The five parameters α, σ, γ, a_1, and a_2 are determined from the observed ionization potentials[4] of a given isoelectronic sequence. The resultant function of Z (first four terms of $I(Z)$) is then extrapolated to the respective negative ion. The remainder, R, must be determined by comparison with experiment and is a percentage correction. If the experimental results on I were more accurate, further coefficients a_3, a_4, etc., of the expansion could be determined, and R could then be estimated theoretically. The present experimental accuracy does not permit such a procedure. In the results given, R was chosen to be 10 per cent.

As a check, the parameter α was found to be very slightly larger than $1/n^2$, where n is the principal quantum number, and σ was also found to be in satisfactory agreement with the screening parameters determined in other contexts[5].

It is to be noted that α and σ are determined by extrapolation of the isoelectronic sequence to large Z,

Table 1. ELECTRON AFFINITIES OF NEGATIVE ATOMIC IONS
(All entries in eV.)

Ion	(1) Quadratic extrapolation	(2) Experiment	(3) Proposed extrapolation
B^-	− 0·089	> 0	0·82
C^-	0·83	1·13 ± 0·15	1·21
N^-	− 0·6 ± 1	< 0 ?	0·54
O^-	0·69	1·465 ± 0·005	1·47
F^-	2·93	3·62 ± 0·09	3·62
Al^-	0·50	> 0	1·19
P^-	0·57	> 0	1·33
S^-	2·07	2·07 ± 0·07	2·79
Cl^-	3·05	3·82 ± 0·06	3·84

the first term being an asymptotic value for $Z \rightarrow \infty$. In the quadratic extrapolation the first three terms of the isoelectronic sequence (lowest Z) are used for determining a quadratic in Z. Therefore, this quadratic cannot be justified as an asymptotic hydrogen-like formula. The parameters a_1 and a_2 play an essential part in the numerical value of the electron affinities.

The results are given in column (3) of Table 1 (the observed ionization potentials for the Si^- sequence are insufficient to apply our method) and are seen to agree within experimental error for all observed cases except S^-. The discrepancy in S^- may be due to incorrect experimental data on the ionization potentials of Cl I and its sequence.

A detailed report of this work will be published elsewhere.

H. R. JOHNSON

Department of Astro-Geophysics,
University of Colorado,
Boulder, Colorado.

F. ROHRLICH

Department of Physics,
Johns Hopkins University,
Baltimore, Maryland.
Nov. 24.

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Magnetic Viscosity displayed on Hysteresis Loop Traces

[illegible]HE earliest measurements relating the rate of [illegible]ge of flux to applied field under pulsed conditions [illegible] made by Sixtus and Tonks[1]. They measured [illegible]ate of propagation along a nickel wire of a wave-[illegible] of flux change and so obtained a measure of [illegible]agnetic 'viscosity'. More recently, Galt[2] has [illegible]rmed similar measurements involving a single [illegible]in wall in a crystal of nickel–iron ferrite. Since [illegible] I have made measurements of magnetic [illegible]sity in polycrystalline magnesium–manganese [illegible]e ('Ferroxcube' *D*1) during continuous hysteresis [illegible] tracing, this particular ferrite exhibiting a [illegible]ngular hysteresis loop.

[illegible]e method used here involved the superposition of pulsed and a.c. magnetizations. This was accomplished with negative feed-back control of the flux wave-form in the specimen, the apparatus used being fully described elsewhere[3]. It is sufficient to remark that with this apparatus over a wide range of frequency the flux wave-form corresponds almost exactly to the voltage applied to the system.

To produce the required pulse, in addition to the sine wave input normally employed, there was superposed at the same frequency a square wave with the slope of its rising and falling edges adjustable over a wide range. Thus for the duration of each edge the change of flux was rapid and constant, and throughout the remainder of the cycle it was much slower.

At the repetition frequency chosen, 330 c./s., the effect of magnetic viscosity was small, although not negligible. The rate of change in the accelerated portion of flux reversal could correspond to applied frequencies as high as 250 kc./s. or as low as 500 c./s. For these two limits, the increases in magnetizing field required were 96 and 3 per cent, respectively, of the coercive force, measured from the static loop.

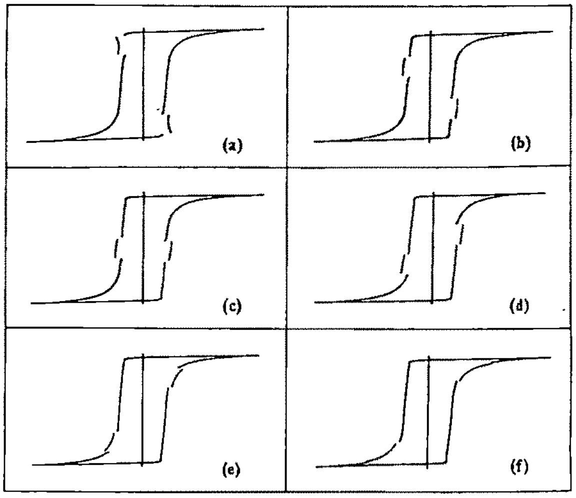

Fig. 1. Hysteresis loops with superimposed a.c. and pulsed excitations

Fig. 1 shows tracings from photographs of hysteresis loops produced by this method. The point of acceleration is shown by an outwards jump in H on the hysteresis loop, and the end of the accelerated portion by a returning jump. For the six different traces the point of acceleration occurs progressively later in the cycle. The accelerated rate of change of B was the same in each, being $1{\cdot}25 \times 10^4$ Wb./m.^{2}/sec. (with $B_m = 0{\cdot}236$ Wb./m.^{2}, $H_m = 500$ amp. turns/m., $H_c = 77$ amp. turns/m.), but it will be seen that the initial step in H progressively decreases from one trace to the next. However, it has been found that the converse is true for the magnitude of the step when measured at the point $B = 0$. In trace (c) this step was 25 amp. turns/m.

The equation $dB/dt = k(H - H_0)$, which is of the same form as those obtained by Sixtus and Tonks and by Galt, was found to apply only when $(H - H_0)$ was large, of the order of 20 amp. turns/m. or more. The constant k was found to vary markedly as the point of acceleration was changed, and to a lesser extent as H_m was varied. The maximum value for k, measured when $B = 0$, was 5×10^3 Wb./m. sec. amp. turns, and its minimum was about 10^3 Wb./m. sec. amp. turns in the linear range; but in the non-linear range when $(H - H_0)$ was small k decreased even further, approaching 10^2 Wb./m. sec. amp. turns.

The departure from linearity at the lower field strengths, which was not experienced by Galt, is apparently due to the polycrystalline nature of the material, which gives rise to a larger number of mobile domain walls. Otherwise, the results for this material, and those obtained by Galt for a single domain wall are of an identical nature.

R. G. GEORGE

King's College,
University of London,
London, W.C.2.
Nov. 27.

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A Microwave Method of determining the Displacement and Velocity of a Piston in a Hypersonic Gun Tunnel

THE 'hypersonic gun tunnel' is a development of the conventional shock tube, giving a comparatively long running time for aerodynamic testing purposes. Its mode of operation has been fully described[1].

A vessel containing gas at high pressure is initially separated from the main tube or gun barrel at a lower pressure by a metal diaphragm and a light piston. When the diaphragm is ruptured, the piston is driven down the barrel and a strong shock wave forms ahead of it. The shock wave is reflected several times between the end of the barrel and the piston before the latter is finally brought to rest, the slug of air ahead of it being heated and compressed in a non-isentropic manner. This region ahead of the piston can experience very high transient pressures and temperatures.

We particularly wished to study the effect of the mass and shape of the piston on the flow parameters.

The displacement and velocity of a nylon piston in the hypersonic gun tunnel at the University of Southampton has been determined by means of a microwave technique[2]. This method has been devised because it provides a large number of test stations (in this instance 120 over 10 ft.) at which displacement and velocity of the piston can be determined.

The technique regards the steel gun barrel as a resonant microwave cavity and the travelling piston as a tuning plunger moving in the cavity. A radially symmetric wave-guide mode (TM_{01}) is established in the 10-ft. long steel gun barrel of 1·25 in. internal diameter. Microwave power obtained from a reflector klystron operating in the 3-cm. commercial band is launched into the barrel by an axial probe through a wave-guide directional coupler, the latter permitting the simultaneous monitoring of the reflected or transmitted wave system with a single aerial. A crystal diode detects the reflected wave signal from the moving nylon piston. The reflexion-coefficient of the piston is increased by facing it with a shim metal disk. The time between successive standing wave minima indicates the time taken for the piston to move through a half guide wave-length. Displacements and velocities have been measured throughout the period of the piston motion.

The oscillogram (Fig. 1) shows variation of crystal diode voltage with time during a typical run; it was taken 4·0 m.sec. after the diaphragm was ruptured. Analysis indicates that the piston is increasing in velocity from 1,445 ft./sec. to 1,490 ft./sec. over a length of barrel of 3·02 in. during a time-interval of 170 μsec. This requires an acceleration of order 265,000 ft./sec.^{2}. The maximum piston velocity so far observed has been 1,700 ft./sec. If the measured signal is deliberately made asymmetric (by alteration of matching) then it is possible to observe a change of signal phase whenever the piston reverses its direction. This effect has been clearly seen during actual runs.

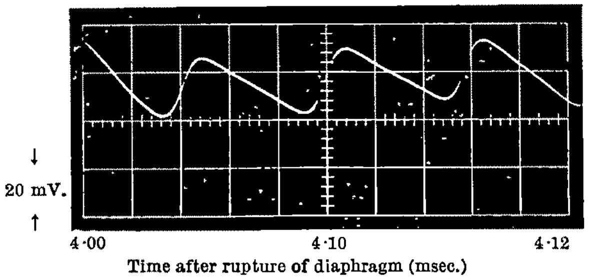

Fig. 1. Variation of crystal diode voltage with time

A raster type of cathode-ray oscillograph display is being developed which will enable the whole run to be recorded, yet have an individual line time-base sufficiently short in duration to enable accurate variations of piston velocity to be determined.

L. PENNELEGION

Department of Aeronautical Engineering,
University of Southampton.

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A 'Solid-Image' Microscope

THE disadvantage of the 'solid-image' microscope described by Gregory and Donaldson[1], as they point out, is that objects are seen through a relatively intense haze of background light, rather as if they were immersed in milk. There is a fairly straightforward way around this difficulty, though it entails a loss of some of the elegant simplicity of Gregory and Donaldson's instrument. During 1948–49 I devised and built at King's College a 3-dimensional scanning microscope on the same basic principle[2], which was described briefly in a report on university research in physics in 1949 [3] and exhibited at the College conversazione in that year. The slide carrier w
vibrated in depth between 10 and 20 times a seco
with a saw-tooth motion, by means of a linear elect
magnetic servo. The object, however, was scann
laterally by a flying spot on a cathode-ray tu
and the signal detected by a photomultiplier, exac
as in the 2-dimensional 'flying spot microscope' la
(and apparently independently) described by Rob
and Young[4] of University College, London.
three deflecting voltages and the photomulti
signal were supplied to a 3-dimensional projec
cathode-ray tube display of the type devised for
in radar and electronic computing[5], so that a 's
representation of the object appeared on the sc
and could be rotated at will by calibrated con
which enabled angles to be read directly.

The crucial advantage of the electronic displa
that the signal can be electronically 'inverted' s
to present a negative picture showing object
white on an otherwise dark background. In
way one could readily see single nuclear par
tracks in emulsion (for the study of which the ins
ment was particularly intended) when in a 'positive' picture they were quite obscured by the bright background.

Work on the instrument was unavoidably interrupted in 1949, but my preliminary conclusion was that the astigmatism due to the inevitably poor depth-resolution must limit its usefulness to the study of fairly simple (preferably linear) structures (such as particle tracks, and perhaps nerve fibres). A severe compromise between signal-to-noise ratio, electronic resolving power, and rate of scanning is determined by the brightness of available flying-spot sources, since even ten pictures a second, with only twenty horizontal 'layers' each, require 200 frames to be scanned each second. At such rates, non-uniform scanning[6] was found to be essential to give acceptable resolution in the centre of the picture, and it seemed unlikely that for a tolerable signal-to-noise ratio, resolving power could equal that of conventional instruments. At lower rates, of course, resolution could be as good, or even (with electronic 'sharpening') a little better.

D. M. MacKay

Wheatstone Physics Laboratory,
King's College, London, W.C.2. Dec. 10.

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We were not aware of Dr. MacKay's most interesting experiments in this field when we constructed our first prototype 'solid image' microscope, and it seems unfortunate that his work was interrupted, and not made generally available.

It should perhaps be stressed that our attempt to produce a 'solid image' is based on purely optical principles. A 'flying spot' technique requires scanning in three dimensions, rather than one only, imposing serious demands on the band-widths available with the single channel involved.

It does not seem impossible to produce brightness 'inversion' by optical means. Thus standard dark-ground illumination gives bright objects in a dark field. We are at present experimenting with various types of illumination, in an attempt to produce acceptable contrast and resolution with magnifications sufficient to reveal such structures as nuclear particle tracks in emulsion and suitably stained nerve fibres.

R. L. Gregory

Psychological Laboratory,
University of Cambridge.

P. E. K. Donaldson

Physiological Laboratory,
University of Cambridge.

Suppressed Light Emission of the Reaction Zone in Detonation

The detonation of high explosives in water can be photographed with an open camera and a flash light as the explosive gases do not emit light. The method has been used[1] to investigate the spread of shock waves and explosive gases, and to investigate the initiation by shock waves[2]. We have found that it can be used also in certain gases such as butane and propane. The method is not suitable, on the other hand, for explosives with two levels of detonation velocity in the case of low velocity. A great part of the reaction then occurs after the reaction zone has passed and the expanding explosive gases are very luminous even in water.

In detonation with high velocity the original surface of the explosive is luminous due to the emission of light at the passage of the reaction zone. The luminosity of the surface is often very heterogeneous. Compressed TNT thus gives a distinctive pattern of small, rather sharply defined surfaces with different light intensities. Sometimes dark coherent sections appear. In transmitting detonation through water between two coaxial cylindrical charges with plane ends, the receptor charge has at its initiating end a dark band which extends right across the charge, and which increases in its axial length with the transmission distance. The detonation in the receptor charge is slightly delayed in starting, and in the meantime the shock wave from the primary charge is propagated and the dark part of the secondary charge is exposed to a high pressure.

Fig. 1 shows clearly how the light emission of the reaction zone is suppressed by an external pressure of water. The experiment was made with a spherical charge of 50 mm. diameter and two cylindrical charges of 20 mm. diameter and a length of 100 mm. in a cubical tank with a 35-cm. edge-length. The charges were of compressed TNT of density 1·53 gm./cm.^{3}. Behind the tank was placed an argon flash with a pentolite charge and a screen of paper which gave a diffuse light. All charges were initiated with detonation fuses and blasting caps, the spherical charge in the centre and the cylindrical charges at their lower end. The detonation fuses were connected to a common fuse, and their lengths were adjusted so that the argon flash was lit when the shock wave from the spherical charge met the detonation front approximately at the middle of the right cylindrical charge. It is evident from Fig. 1 that the light emission diminishes very rapidly when the reaction zone enters the pressure field of the shock wave from the spherical charge. The pressure was about 2,500 atmospheres. The left cylinder charge was initiated later, and its boundary line is therefore somewhat lower down.

To determine whether the dark part of the charges detonates in a normal manner, an experiment was made with a charge of two cylinders joined at right angles (Fig. 2). It was initiated at the lower end of the right leg so that the detonation-front met the shock wave from the spherical charge below the angle joint. The charge is dark above the intersecting line, but the detonation proceeded round the corner and on its downward course along the left leg it passed the shock wave. Below the passage line the charge again becomes luminous. In this experiment the flash was lit when the detonation front was in the dark part of the charge. The outgoing shock wave gives further confirmation that the dark part of the charge detonated in a normal manner.

Measurement of the porosity of the TNT charges has given values between 5 and 8 per cent by volume. It seems reasonable to assume that the pores of the surface layer become filled with water when the shock wave passes, and that as a consequence the luminosity weakens. It was found, however, that evacuated and water-filled charges gave a similar pattern to that of charges with air-filled pores, although the luminosity was weaker. Further, the suppression of light was about the same in cast as in compressed TNT. Part of the black-out may therefore be directly due to the pressure.

For cast pentolite with 60 per cent PETN and 40 per cent TNT the emission of light is also

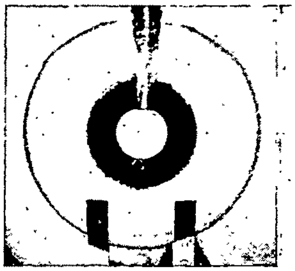

Fig. 1

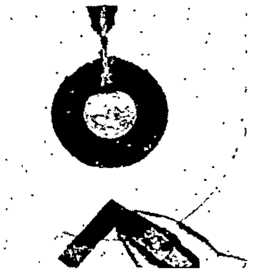

Fig. 2

diminished by a shock wave in water, but the effect is less than for TNT. Compressed PETN shows no decrease in the luminous intensity.

We wish to thank Mr. T. Edlund, manager of the Nitroglycerine Company, for permission to publish this work.

C. H. Johansson
L. Sternhoff

Physical Research Department,
Nitroglycerin AB.,
Stockholm. Dec. 8.

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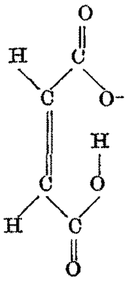
CHEMISTRY

Intramolecular Hydrogen Bonding in Heterocyclic Systems

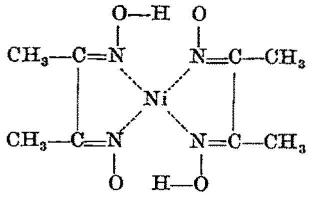
The hydrogen bond is usually described as unsymmetrical, with the hydrogen atom nearer one of the two bonding atoms, and the energy of bonding is considered as due to electrostatic and delocalization energy. The principal valency bond structures considered are I, II and III, and it has been shown[1] that when the O—O distance is 2·5 A. these three structures have the relative weights 60·3, 28·4 and 11·3. Resonance of a purely covalent character is not considered to play a part as this would require the hydrogen atom to be symmetrically placed between the two bonded atoms, and Donohue[2], by extrapolating Pauling's bond-order/bond-length relationship, has calculated that for such a bond the O—O distance could not exceed 2·4 A. However, most of the detailed studies of this problem have been concerned with intermolecular hydrogen bonds, and it is suggested here that in the cyclic systems involved in intramolecular hydrogen bonds, covalent forces play a much larger part.

$$\underset{\text{(I)}}{\text{—O—H}\cdots\text{O}} \qquad \underset{\text{(II)}}{\text{—}\overset{-}{\text{O}}\ \overset{+}{\text{H}}\cdots\text{O}} \qquad \underset{\text{(III)}}{\text{—}\overset{-}{\text{O}}\quad \text{H—}\overset{+}{\text{O}}}$$

It has been pointed out[3,4] that if covalent forces played an appreciable part in hydrogen bonding, considerable alterations in the O—H stretching band in the infra-red would be expected. In the case of intermolecular hydrogen bonds the shifts in the O—H band from 3,200 cm.$^{-1}$ are usually small, and the intensity of the band is increased; but in several cases of intramolecular hydrogen bonding, the O—H band has been very drastically shifted and its intensity greatly diminished. Cardwell, Dunitz and Orgel[5] noted that the O—O distance in the hydrogen maleate ion IV should be very short (less than 2·45 A.), and that the infra-red spectrum revealed no detectable absorption from 5,000 cm.$^{-1}$ to 1,575 cm.$^{-1}$. The *bis*-dimethylglyoximinate nickel[6] or cobalt[7] complex V has an O—O distance of 2·44 A. and its O—H stretching band greatly weakened and displaced to 1,900 cm.$^{-1}$.



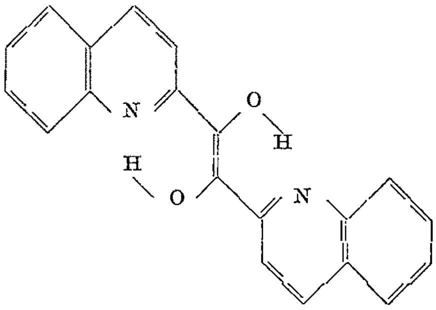
(IV)



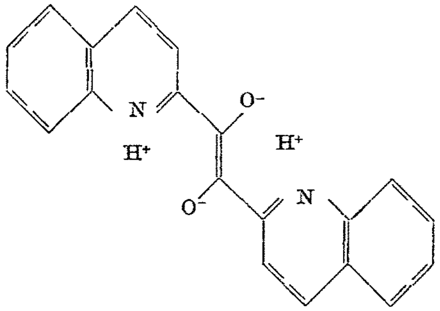
(V)

The effect of covalent resonating forms would be expected to be greater in compounds where the hydrogen bonded system could become part of an extended resonating system, and we have, therefore, examined the infra-red spectra of some heterocyclic intramolecular hydrogen bonded compounds, for example, 1,2-di-2′-quinolylethene-1,2-diol (quinaldoin), VI, deoxyquinaldoin, VII, and 1,2-di-3′-*iso*quinolylethene-1,2-diol, VIII. In these compounds the OH, NH and C=O vibrations are so modified that none of the compounds shows any absorption between 5,000 cm.$^{-1}$ and 1,625 cm.$^{-1}$.

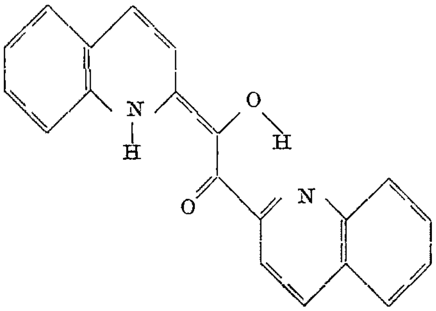
It is suggested that the lack of any absorption before 1,600 cm.$^{-1}$ in the compounds studied is due to intramolecular hydrogen bonding, stabilized by considerable resonance contributions from covalent forms (VI*a*, *c*) and facilitated by the cyclic nature of the system, that is, an essentially non-polar hydrogen bond. It has been shown[8] that the equilibrium O—H distance increases exponentially as a second electronegative atom approaches. Calculations assuming normal bond-lengths and bond-angles of 120° show that the O—N distance in these molecules lies be-



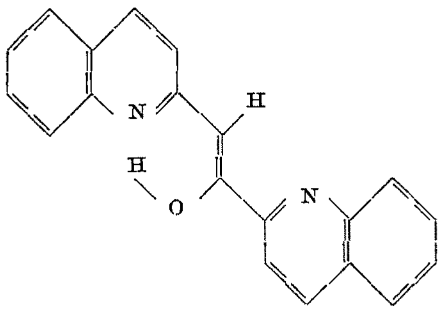
(VI*a*)



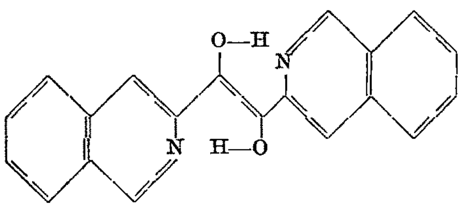
(VI*b*)



(VI*c*)



(VII)



(VIII)

tween 2·41 and 2·45 A., depending on the degree of double-bond character assumed. Taking the O—N distance to be 2·45 A. and the equilibrium O—H distance to be 1·15 A., Coulson and Danielsson's[1] method of calculation gives the relative weights of VI*a*, *b* and *c* as 52·2, 20·1 and 27·7, respectively. The covalent form VI*c* therefore makes a very real contribution. Due to the cyclic form of the hydrogen-bonded system electron delocalization does not involve charge transfer, and therefore the intensity of the O—H band is diminished, in contrast to the increase in intensity observed in intermolecular hydrogen bonds, where charge transfer does occur (III). This explanation could also be applied to the anomalous infra-red spectra of 2-phenacylpyridine derivatives[9], β-keto enols and β-iminoketones[10].

We therefore suggest that where resonance is possible in intramolecular hydrogen bonds in heterocyclic systems, covalent forces play a considerable part and that such systems[11] would repay further study, particularly with reference to the interatomic distances involved.

Infra-red spectra were measured in bromophthalene and perfluorkerosene pastes so there would be no possibility of a weak band being masked by the CH absorption of paraffin at 2,900 cm.$^{-1}$.

We wish to thank Dr. D. Ll. Hammick for his kind encouragement, and Mr. R. Wolley for his assistance with some of the experimental work.

E. W. GILL
E. D. MORGAN

Dyson Perrins Laboratory,
South Parks Road,
Oxford. Dec. 9.

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Heterogeneous Atomization of Hydrogen and Oxygen

BECAUSE of its chemical simplicity, the process of atomization of hydrogen at a surface is free from many of the ill-defined parameters which are important in more complicated heterogeneous reactions and which make their interpretation equivocal. The reaction over tungsten was discovered by Langmuir[1] and investigated quantitatively by Bryce[2] and Ivanoiskaya and Mochan[3]. The experimental arrangement employed by these authors consisted of a tungsten filament suspended in hydrogen, the wall of the reaction vessel being coated with a hydrogen-atom trapping agent so that the reaction velocity could be determined by the measurement of the rate of fall in the pressure of hydrogen. Bryce used molybdenum oxide as the hydrogen-atom trap, while Ivanoiskaya and Mochan used potassium. They found that the rate of atomization was accurately proportional to $\sqrt{P}$ in the pressure range 10^{-2}–10^{-3} mm. of mercury and the energy of activation (E) was 45 kcal./mol. or rather less.

Two atomization mechanisms are possible :

$$W - \mathrm{H} \rightarrow W + \mathrm{H} \tag{1}$$

$$\mathrm{H}_2 + W \rightarrow W - \mathrm{H} + \mathrm{H} \tag{2}$$

where W denotes the tungsten surface and $W - \mathrm{H}$ an atom of hydrogen adsorbed thereon. The assumption is made that the equilibrium $\mathrm{H}_2 + 2W \rightleftharpoons 2W - \mathrm{H}$ is effectively maintained throughout the reaction. Roberts and Bryce[4] applied the principle of detailed balancing to the two possibilities and showed that mechanism 1 yielded $\sqrt{P}$ kinetics only for $\theta \ll 1$, while mechanism 2 required $\theta \sim 1$ for this result, but in each case $E = \frac{1}{2}D(\mathrm{H}_2)$. Immobility of the adsorbed layer is implicit in their discussion. Miller[5] and Laidler and his co-workers[6] have discussed the reaction from the statistical point of view. Mechanism 2 has been consistently and, as we now believe, incorrectly favoured in these treatments.

The fact that neither mechanism 1 nor 2 was capable of adequately describing the experimental results encouraged us to repeat the investigation of the kinetics of the reaction. Molybdenum oxide was employed under carefully controlled conditions as the hydrogen-atom trap, and the vacuum technique was such as to ensure clean surfaces. The $\sqrt{P}$ rate law was found to be obeyed over the pressure-range 10^{-2}–10^{-6} mm. at about 1,200° K. and the fully corrected value of E was $52 \cdot 6 \pm 1 \cdot 0$ kcal./mol. at about 1,200° K., these observations being combined in the equation :

$$\text{rate of atomization} = 18 \times 10^{24}\,(P_{\mathrm{H}_2}\ \text{mm.})^{1/2}\ \exp(-52600/RT)\ \text{atoms cm.}^{-2}\ \text{sec.}^{-1}$$

These findings are compatible only with mechanism 1. An analysis of the atomization and recombination processes indicates that the adsorbed layer of hydrogen has complete two-dimensional freedom on the surface at these temperatures and further, that the ratio of atomic to molecular hydrogen desorbed from the surface has the value predicted by the equilibrium constant (K) for the reaction $\mathrm{H}_2 \rightleftharpoons 2\mathrm{H}$, the temperature and molecular pressure being that of the filament and the ambient gas respectively (cf. Doty[7]).

These new results have two important consequences. First, the reaction is expected to become first order with respect to the molecular hydrogen pressure at a sufficiently low value of P_{H_2}/K, and this change in rate law has been observed in the expected region, namely, 10^{-6} mm. at 1,800° K. Secondly, the rate is independent of coverage; it is thus independent of surface structure and is determined solely by the area exposed to molecular hydrogen. A study of the atomization of hydrogen over platinum and gold supports this view.

We have also studied the atomization of oxygen over platinum using a reduced form of molybdenum oxide as the oxygen-atom trap. Again, $\sqrt{P}$ kinetics are found over an extended pressure-range and the activation energy is accurately $\frac{1}{2}D(O_2)$. Thus the present investigation, the details of which will be published later, support mechanism 1 as the process by which both hydrogen and oxygen are atomized heterogeneously.

We are grateful to Dr. B. M. W. Trapnell for initiating this investigation and to the Billingham Division of the Imperial Chemical Industries, Ltd., for financial support. We also wish to thank Dr. T. B. Grimley for much valuable discussion.

D. BRENNAN
P. C. FLETCHER

Department of Inorganic and
Physical Chemistry,
University of Liverpool.
Nov. 26.

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Analysis of Light Hydrocarbon Gas Mixtures

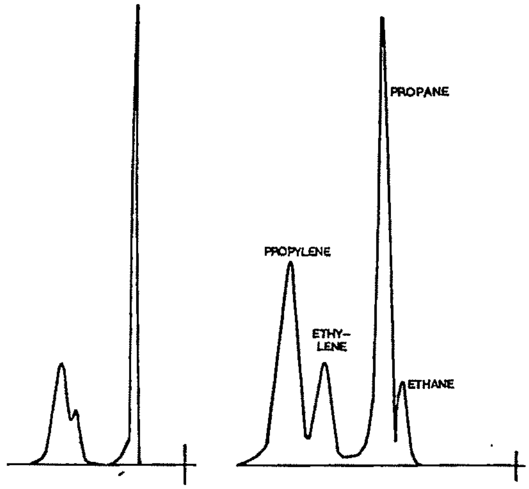
IT is a common analytical requirement to separate mixtures containing ethane, ethylene, propane and propylene, and, while gas chromatographic methods have been designed to separate the C_2 and C_3 gases and also the olefines from the saturated compounds, there is not, in our experience, any simple method reported for the resolution of all four gases on one column.

Olefines are cleanly separated from the saturated hydrocarbons on a column packing consisting of a saturated solution of silver nitrate in ethylene glycol supported on graded 'Celite'[1]. The C_2 gases are separated from the C_3 by a tri-*iso*butylene/'Celite' column[2]. Attempts to achieve separations by use of these two columns in series were unsuccessful (Fig. 1*a*), as were similar attempts by Bednas and Russell[2].

The technique of using a physical mixture of these two packings in one column was therefore tried. The two packings, prepared separately as before, were mixed together mechanically; this did not appear to impair their efficiency or useful life in any way. On a W-shaped column, 4 m. long × 6 mm. internal diameter, separation of all four gases was readily accomplished at room temperature and Fig. 1*b* shows a typical chromatogram obtained with this mixed packing.

The same mixture was used for each run.

Column dimensions: 4 m. × 6 mm. internal diameter; carrier gas: 0·4 l./hr. nitrogen; inlet pressure: 758 mm.; outlet pressure: 712 mm.; column and katharometer temperature: 25° C. So far as we are aware this is the first occasion on which the use of such a physically mixed packing has been reported.



(*a*) (*b*)

Fig. 1. *a*, Series columns; *b*, mixed packing

Further work has shown that it is also quite possible to separate *iso*butene from the four gases previously mentioned on the same column.

J. A. BARNARD
H. W. D. HUGHES

Department of Chemical Engineering,
University College,
London, W.C.1.
Dec. 5.

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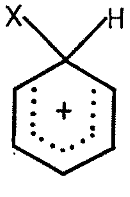
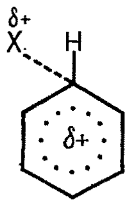
Kinetic Isotope Effect in the Bromination of Dimethylaniline

THE recent account by Shilov and Weinstein[1] of a kinetic isotope effect in the iodination of some aromatic amines prompts us to report the observation of a similar effect in the bromination of dimethylaniline.

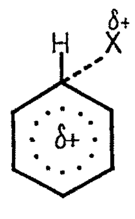
The absence of a hydrogen isotope effect in the iodine-catalysed reaction between molecular bromine and benzene[2] shows that the C—H bond at the position of substitution is not appreciably stretched in the transition state, though the bond may have changed its hybrid character from sp^2 to sp^3, forming the Wheland intermediate[3] (I, X = Br). Other studies[4] have indicated that, in general, the degree to which the Wheland intermediate is formed in the



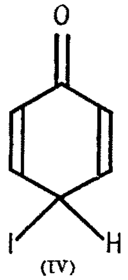
(I)



(II)



(III)



(IV)

Table 1. LOGARITHMS OF THE FREQUENCY FACTORS (LOG *PZ*) FOR THE REACTION OF BENZENE, DIPHENYL, NAPHTHALENE AND PHENANTHRENE WITH CHLORINE IN ACETIC ACID SOLUTION BETWEEN 15 AND 30° C.

Hydrocarbon	Log *PZ*
Benzene	9
Diphenyl	7·8
Naphthalene	7·3
Phenanthrene	7·4

transition state for aromatic substitution is only partial (for example, II). If the degree of formation of the intermediate in the transition state were constant in a series of aromatic hydrocarbons for a given reagent, the frequency factor of the reaction should increase with the size of the hydrocarbon, as the positive charge would be more dispersed in the transition states of the larger aromatic molecules, and the entropy of activation due to solvation would be correspondingly smaller. However, the contrary trend has been observed[5] (Table 1), suggesting that the more reactive the aromatic hydrocarbon, the more completely formed is the Wheland intermediate in the transition state for aromatic halogenation.

With a very reactive aromatic compound it appeared possible that the passage from the Wheland intermediate to the products, that is, C—H bond-breaking, might become the rate-determining step of a halogenation reaction (for example, III), so that a kinetic hydrogen isotope effect would be observed. Prior to the work of Shilov and Weinstein[1], all kinetic isotope effects found in aromatic substitution reactions could be ascribed[6] to rate-determining C—H bond-breaking in relatively stable neutral or zwitterionic intermediates (for example, IV). To obviate such a possibility in the present study, dimethylaniline was selected as the reactive aromatic compound, and molecular bromine was chosen as the substituting reagent, since the absence of a kinetic isotope effect with this reagent had been demonstrated in the case of benzene[2]. 2,4,6-Trideuterodimethylaniline was prepared by five successive exchanges of dimethylaniline sulphate with deuterium oxide at 100° C., the extent of the exchange, as measured by infra-red spectroscopy, being more than 90 per cent. The rates of reaction of dimethylaniline and its 2,4,6-trideutero-derivative (0·005 and 0·0075 *M*) with bromine (0·003 *M*) were measured at 25 ± 0·01° C. in aqueous sulphuric acid (6·4 *M*) containing an excess of bromide ions (0·025 *M*) by Bell and Ramsden's method[7]. At both amine concentrations a kinetic isotope effect (k_H/k_D) of 1·8 was observed. With the absence of such an effect in the bromination of benzene[2], the present result suggests, like the trend of the frequency factors for the reaction of chlorine with the aromatic hydrocarbons (Table 1), that the nature of the transition state in aromatic substitution varies not only with the substituting reagent[4] but also with the aromatic molecule attacked, showing less resemblance to the reactants in the case of the more reactive aromatic compounds.

P. G. FARRELL
S. F. MASON

Chemistry Department,
The University,
Exeter.

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Exchange Reaction induced by Radiation between Diethyl Sulphate and Labelled Sulphuric Acid : a Possibly Ionic Reaction

ALTHOUGH ionization reactions represent one of the most important processes in the interaction of radiation with matter, relatively little interest has been shown in reactions involving ionic species with the exception of the ion-molecule reactions recently much discussed[1]. Since ionization is one of the most important processes in the interaction of radiation with matter, it is felt that a study of reactions possibly involving ionic intermediates may provide a most interesting and perhaps fruitful area of radiation research. One such system appears to be the exchange reaction induced by radiation between diethyl sulphate and radioactive sulphate ion, where any appreciable formation of diethyl sulphate-^{35}S may conceivably require $C_2H_5^+$ as an intermediate.

In our experiments, commercial diethyl sulphate was purified by vacuum distillation. Aliquots of sulphuric acid labelled with sulphur-35 (0·2–0·5 mc.) and unlabelled sulphuric acid carrier were evaporated in glass irradiation-cells and 2 ml. of the purified diethyl sulphate was added, after which the cells were evacuated and sealed off. The samples were irradiated with a cobalt-60 source (~1·5 × 10^5 r./hr.), returned to the vacuum line for pressure measurements, and finally the organic phase was purified to check for any exchange reactions.

The irradiated samples were treated in the following manner. Unincorporated sulphuric acid-^{35}S and any ethyl hydrogen sulphate-^{35}S formed were extracted from the organic phase by means of carriers in the form of aqueous sulphuric acid. The extraction was continued until the sulphur-35 activity in the extractant became negligible. After the extractions, the diethyl sulphate was further purified by double distillation on the manifold and hydrolysed to the inorganic sulphate by vigorous refluxing with alcoholic sodium hydroxide. The $^{35}SO_4^{=}$ so obtained was precipitated with barium chloride and counted as infinitely thick samples using an end-window Geiger–Müller tube and a scaler in the standard manner[2].

Table 1. RADIATION-INDUCED EXCHANGE BETWEEN $(C_2H_5)_2SO_4$ AND $H_2{}^{35}SO_4$

The samples used consisted of 2·5 × 10^{-6} mole of sulphuric acid (containing 200–400 µc. of sulphur-35) in 1·54 × 10^{-2} moles of diethyl sulphate (2 ml.). All samples were allowed to stand for the same length of time before processing

Irradiation dose (rads)	10^{3}*	8 × 10^{6}	2·56 × 10^{7}
Average percentage of sulphur-35 activity incorporated	0·9	3·5	6·9

* Due to the sulphur-35 beta activity

For control purposes, unirradiated samples were also processed and counted in an identical manner. The results (Table 1) show that the cobalt-60 irradiated samples undergo a considerably greater exchange than the samples which were not irradiated with the cobalt-60 source. The enhanced extent of exchange by irradiation suggests the possible presence of either (*a*) reactions involving ionized molecules of diethyl sulphate and their dissociation products, for example, the $C_2H_5^+$ ion, or (*b*) reactions involving the $C_2H_5\cdot$ radical and the $^{35}SO_4$: biradical. If ionic species were involved, the probable reactions would be :

$$(C_2H_5)_2SO_4 \rightsquigarrow (C_2H_5)_2SO_4^{+} + e^{-}$$

$$(C_2H_5)_2SO_4 + e^{-} \rightarrow (C_2H_5)_2SO_4^{-}$$

$$(C_2H_5)_2SO_4^{+} + {}^{35}SO_4^{=} \rightarrow C_2H_5SO_4 + C_2H_5{}^{35}SO_4^{-}$$

$$C_2H_5SO_4 \longrightarrow \text{dissociation products}$$

$$C_2H_5{}^{35}SO_4^{-} + (C_2H_5)_2SO_4^{+} \longrightarrow (C_2H_5)_2{}^{35}SO_4 + C_2H_5SO_4$$

$$C_2H_5^{+} + {}^{35}SO_4^{=} \rightarrow C_2H_5{}^{35}SO_4^{-} \xrightarrow{+C_2H_5^{+}} (C_2H_5)_2{}^{35}SO_4$$

In spite of the rather low concentration of the ionic species involved (about 10^{17} sulphuric acid molecules or ions versus about 10^{22} diethyl sulphate molecules per ml.) the exchange reaction appears to be a relatively efficient process. Possible applications of these reactions may be (*a*) tagging of various sulphur compounds as well as substances which cannot be conveniently tagged by other techniques and (*b*) studying of the behaviour of ionic species produced by radiation in a liquid system.

PAUL Y. FENG
AHREN JACOBSON*

Physics Research Department,
Armour Research Foundation,
Chicago 16, Illinois.
Oct. 15.

* Present address: Hines Veterans' Administration Hospital, Hines, Illinois.

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Peak Dimensions in Gas Chromatography

WHATMOUGH'S observations[1] can be explained if the absorption isotherms of his packing material are non-linear and if one takes account of variations of flow velocity in the column[2].

At a point where the vapour concentration is c let the total quantity of vapour, including that absorbed, be q per unit volume of free space. If the flow velocity is u, then:

$$\frac{dq}{dt} - \frac{dc}{dt} = -\frac{du}{dx} \tag{1}$$

If local equilibrium is attained instantaneously and longitudinal diffusion is negligible, then:

$$\frac{d(uc)}{dc}\left(1 - \frac{dc}{dq}\right) = \frac{du}{dc} \tag{2}$$

If u_0 is the velocity in regions containing pure carrier gas, then since q is a function of c, it is clear from (2) that u/u_0 is also a function of c. Take the case of a packing in which:

$$q = c + \frac{\sigma c}{1 + \alpha c} \tag{3}$$

If the column is being saturated by passing in a mixture of concentration c, then the quantity of gas entering per unit volume saturated is:

$$1 + \frac{\sigma}{1 + \alpha c} \tag{4}$$

and the quantity of carrier gas leaving the exit is:

$$1 + \frac{\sigma(1 - c)}{(1 + \alpha c)} \tag{5}$$

This gives:

$$\frac{u}{u_0} = \frac{1 + \sigma + \alpha c}{1 + \sigma + \alpha c - \sigma c} \tag{6}$$

The rate of advance of the front is:

$$u_0(1 + \alpha c)/(1 + \sigma + \alpha c - \sigma c) \tag{7}$$

At small concentrations the rate of advance is $u_0/(1 + \sigma)$; let $X = u_0t/(1 + \sigma)$ and let time be measured from the instant that the injection of a sample is complete. If q is assumed to be a function of x/X in the regions where it is neither zero nor constant, then:

$$\frac{\partial q}{\partial X} = -\frac{x}{X}\cdot\frac{\partial q}{\partial x} = -\frac{1 + \sigma}{u_0}\cdot\frac{\partial(uc)}{\partial x}$$

$$\text{whence } \frac{x}{X} = (1 + \sigma)\frac{d}{dc}\left(\frac{u}{u_0}c\right)\Big/\frac{dq}{dc} \tag{8}$$

c is zero when $x < X$ and beyond this point increases nearly linearly at a rate inversely proportional to X. This continues until $c = c_0$, the sample concentration, or until the front is reached at some lower concentration c_m. The front remains sharp. If L is the length of the column, then the total quantity of vapour leaving the exit per unit free cross-section is given by:

$$Q = \int uc\,dt = (1 + \sigma)\int_0^{c_m}\frac{u}{u_0}\,c\cdot\frac{d(L - X)}{dc}\,dc \tag{9}$$

From (3) $\frac{dq}{dc} = 1 + \frac{\sigma}{(1 + \alpha c)^2}$ and from (6) and (8) it is possible to evaluate (9).

If L is long enough to make c_m less than c_0 then:

$$\frac{1}{c_m} - \frac{\sigma\alpha c_m}{2(1 + \sigma)^2} + \ldots = \left\{\frac{L\sigma(1 + \alpha)}{Q}\right\}^{1/2} - \alpha \tag{10}$$

In practical cases the term in c_m will be negligible.

The quantity of vapour deduced from the area of a recorder peak is given by:

$$Q' = u_0\int c\,dt \tag{11}$$

To a sufficient approximation:

$$Q' = Q\left(1 - \frac{2}{3}\cdot\frac{\sigma}{1 + \sigma}c_m\right) \tag{12}$$

Taking the ratio of peak area to peak height as a measure of peak width:

$$\frac{Q'}{c_m} = \left\{QL\sigma(1 + \alpha)\right\}^{1/2} - Q\left(\alpha + \frac{2}{3}\cdot\frac{\sigma}{1 + \sigma}\right) \tag{13}$$

This is a maximum when:

$$\left\{\frac{L\sigma(1 + \alpha)}{Q}\right\}^{1/2} = 2\alpha + \frac{4}{3}\cdot\frac{\sigma}{1 + \sigma} \tag{14}$$

The value of dc_m/dQ is a minimum when:

$$\left\{\frac{L\sigma(1 + \alpha)}{Q}\right\}^{1/2} = 3\alpha \tag{15}$$

Whatmough uses an arbitrary concentration scale so that quantitative comparisons are impossible, but for values of c_0 exceeding 0·2 his peak maxima are well represented by:

$$\frac{K}{c_m} = \left(\frac{15}{c_0}\right)^{1/2} - 1 \tag{16}$$

Diffusion has little influence on peak width if Q is large; but if it is small, diffusion predominates and gives an almost Gaussian distribution with a maximum proportional to Q; this accounts for the linear start of his peak height curve.

From (16) the minimum value of dc_m/dc_0 should occur when $c_0 = 5/3$ and the maximum peak width at a not very different value; this accounts for the straightening of the peak height curve and the slow change of width at high values of c_0.

C. H. Bosanquet

Imperial Chemical Industries, Ltd.,
Billingham, Co. Durham.
Oct. 20.

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GEOLOGY and MINERALOGY

Structural Control of Polymorphism in Micas

The extensive polymorphism shown to exist among the mica minerals by Hendricks and Jefferson[1] has been confirmed by a number of workers in more recent years[2,3]. Polymorphism similarly has been clearly demonstrated for other layer lattice silicates, for example, for the chlorites by Brindley, Oughton and Robinson[4].

It is well known that micaceous minerals can form polymorphs principally because the surfaces of the individual silicate layers are composed of oxygen atoms arranged in hexagonal networks. Thus the successive layers can be superimposed or stacked in a number of different ways, in each of which the two hexagonal layer surfaces pack together identically, oxygen to oxygen; but these different ways of layer stacking can give rise to different symmetries and unit cells in the total structure. The successive layers may be regarded as being related to each other by regular rotations between layers, this being geometrically equivalent to regular translations of successive layers along either the a-axis or the b-axis or both. (The concept of rotations between layers is geometrically simpler, but that of translations may be more acceptable physically.)

Smith and Yoder[5] have developed a theory based on these ideas to predict all the possible polymorphs of micas which may occur. They have shown that there are six simple ways of stacking mica layers in an ordered manner, these being based on "inter-layer stacking angles" as follows: $1M$ (one-layer monoclinic) on 0° stacking angles, $2M_1$ on alternating 120° and 240° angles, $3T$ (three-layer trigonal) on 120°, $2O$ (two-layer orthorhombic) on 180°, $2M_2$ on alternating 60° and 300°, and $6H$ (six-layer hexagonal) on 60° angles. While Smith and Yoder discussed the possible factors governing the growth of various polymorphs (including forces due to distortions of the hexagonal oxygen networks) it was not possible to explain, on the evidence then available, their observed relative abundance. It was noted, however, that only the $1M$, $2M_1$, and $3T$ polymorphs are common in Nature, and that $2O$ and $6H$ specimens had not been found at all. Lepidolite specimens crystallizing with the $2M_2$ structure have been described by Levinson[2] and others.

The rarity or non-occurrence of the $2O$, $2M_2$ and $6H$ mica polymorphs appears to me to be explained fairly satisfactorily by the observed departures of layer-lattice silicates from their ideal structures, as reported in several recent analyses (of vermiculite[6], of dickite[7] and of amesite[8]). In each of these the oxygen network is distorted from a hexagonal array to one in which the oxygen atoms are arranged on two interpenetrating triangles of different sizes. For vermiculite these are two isosceles triangles with the equal sides 4·35 and 4·84 A. respectively; but it is to be noted that both triangles are very nearly equilateral. Mathieson and Walker point out that the distortion can be viewed as due to a rotation of triads of oxygen of about 5½°. I am at present re-investigating the $2M_1$ muscovite structure; and while the atomic parameters are not finally fixed it is clear that a similar—though probably greater—distortion of the oxygen network exists in this mica.

The net effect of such distortions is to lower the symmetry of the surface layer from hexagonal to approximately, though not precisely, trigonal. Those polymorphs which result from interlayer stacking angles of 0°, 120° or 240° may therefore occur fairly readily, though their relative abundance may depend on how nearly trigonal the oxygen network is in a given mineral. But those polymorphs based on angles of 60°, 180° or 300° may be expected to occur infrequently (and only as fine-grained specimens), since considerable adjustments of oxygen positions on each layer face would be necessary.

The above argument seems to be supported by the fact that the $2M_2$ mica structure has only been observed for lepidolites. Smith and Yoder[5] pointed out the controlling effect of the linked array of SiO_4 and AlO_4 tetrahedra on the dimensions of the micas; and Newnham and Brindley[7] have attributed the rotations of these tetrahedra in dickite to the misfit of the 'oversize' tetrahedral layer on to the smaller octahedral layer. The lepidolites have less tetrahedral aluminium-for-silicon substitution than other micas, and this layer will thus have dimensions more nearly equal to the (smaller) octahedral layer.

It may be expected that there will therefore be less strain in lepidolites due to tetrahedral–octahedral misfit. This suggests that the oxygen configuration will show a smaller degree of distortion from the ideal hexagonal symmetry, thus allowing a polymorph based on 60° rotations (such as $2M_2$) to occur.

This hypothesis can, of course, only be tested satisfactorily by an accurate analysis of the $2M_2$ lepidolite structure.

For micas other than lepidolites and brittle micas the tetrahedral layer has cation composition $Si_{3/4}Al_{1/4}$, and this network, according to Smith and Yoder[5], should have b-dimensions of $9 \cdot 30 \pm 0 \cdot 06$ A. There will be little distortion of the oxygen hexagons in those micas having a b-axis close to this value (for example, phlogopites and some biotites). If the above argument is valid then the $2O$, $2M_2$ and $6H$ polymorphs may occur among these micas.

E. W. Radoslovich

Division of Soils,
Commonwealth Scientific and
Industrial Research Organization,
Adelaide.

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Some Palæomagnetic Investigations on Chinese Rocks

Previous palæomagnetic investigations[1] on European and North American rocks agree in suggesting that those areas were in such a position that the pole appeared to lie on or near the Chinese mainland from Upper Palæozoic to Mesozoic times. If the geology of China is examined for those same periods, the climate indicated is more equatorial than polar[2]. These two apparently contradictory facts make the palæomagnetic study of Chinese rocks particularly interesting, and account for the publication of the results of the first collection from China despite the small number of samples.

The collection was comprised of some eleven samples, of which eight were of the Tertiary Kansu Series collected at three sites in Kansu, while the remaining three were of red Middle Silurian siltstones from the southern part of Yumen, Kansu province. The Tertiary rocks unfortunately were magnetically unstable, being characterized by low intensities of magnetization and scattered results. The measurements on the Silurian rocks yielded a more consistent pattern (Fig. 1). The mean declination was N. 66·4° W., mean inclination + 55·3°, with a circle of confidence of 8·5° calculated from 17 measured disks. The mean intensity of magnetization was $8 \cdot 8 \pm 3 \cdot 8 \times 10^{-6}$ e.m.u./cm.[3].

The position of the ancient pole was 168° W. 49° S. or 12° E. 49° N., which compares with the Silurian pole from North America of 138° E. 19° N. and by extrapolation an estimated position of a European pole in 165° E. 22° N. If this Chinese result is confirmed by further collections, the following implication, first suggested by Nairn[3] as a result of comparing Permian palæoclimatic and palæomagnetic data, would seem to be valid, namely, that differential movement occurred between Europe and North America and Eastern Asia. This is a significant addition to the Continental Drift theory, for it implies that at the time when Gondwanaland was a single unit, China at least was not part of the Laurasian continent. Further investigation of this possibility is at present in progress.

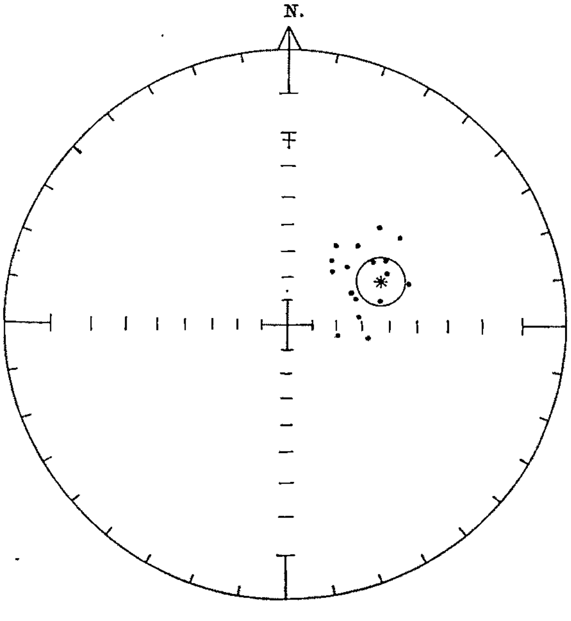

Fig. 1. Stereographic plot of palæomagnetic measurements on middle Silurian rocks from Kansu province. ●, N. pole pointing down; +, theoretical dipole field at the site; *, mean direction of magnetization enclosed within the circle of confidence

Chang Wen-You

Institute of Geology,
Academia Sinica,
Peking.

A. E. M. Nairn

Department of Physics,
King's College,
Newcastle upon Tyne 1.

Nov. 29.

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Chemical Composition of Tektites

In a recent communication[1], Prof. H. Urey makes the following statement: "Tektites have chemical compositions remarkably similar to those of the more acid sedimentary rocks. This is true for the major and minor constituents. (I have been privileged to see analyses as yet unpublished on these minor constituents.) Such a chemical composition is not produced by any other naturally occurring chemical processes that we know of, except perhaps in very rare and special circumstances". Similar statements have appeared in other papers dealing with tektites, and give the impression that their compositions can be explained only by the fusion of sedimentary rocks.

One may reasonably ask which are these "more acid sedimentary rocks" to which Prof. Urey refers. I do not know any publication in which analyses of tektites are directly compared with those of sedimentary rocks. The most comprehensive compilation of tektite analyses is that of Barnes[2]. In discussing these analyses Barnes applies certain criteria for suspecting a sedimentary origin from the chemical composition (excess of aluminium oxide, potassium oxide > sodium oxide combined with magnesium oxide > calcium oxide and very great excess of silicon dioxide). On the basis of these criteria he concluded that: "There is a strong suggestion that Darwin glass, bediasites, and possibly the moldavites and Ivory Coast tektites are fused sediments. The indochinites, billitonites, and australites on this basis are most closely allied to the igneous rocks".

Nevertheless, a rapid survey of published analyses shows the existence of igneous rocks of comparable composition to each of the principal tektite types (Table 1). The igneous rock analyses were selected from Washington's compilation[3], the tektite analyses from Barnes's monograph[2]. An analysis of each tektite type is paired with the analysis of an igneous rock; the correlation within each pair is on the whole very close.

It is incumbent on those claiming near identity of composition between tektites and sedimentary rocks to show that an equally close correlation is possible between these tektite analyses and analyses of individual sedimentary rocks. Even if such a correlation can be established, it should be clear from Table 1 that material with the chemical composition of tektites can be produced by more than one naturally occurring chemical process. To argue that the chemical composition of tektites indicates that they

Table 1

	*A*1	*A*2	*B*1	*B*2	*C*1	*C*2	*D*1	*D*2	*E*1	*E*2	*F*1	*F*2	*G*1	*G*2
SiO_2	97·58	96·16	86·34	81·25	80·52	80·55	77·76	76·71	72·39	72·40	72·40	71·62	68·60	68·90
Al_2O_3	1·54	1·31	7·82	9·03	9·44	9·87	13·30	12·81	13·12	12·56	12·68	12·81	15·80	13·39
Fe_2O_3	0·11	0·02	0·63	0·63	—	2·13	0·37	0·80	0·42	none	0·23	1·64	0·18	3·45
FeO	0·23	0·09	2·08	0·40	1·98	—	3·36	1·72	4·48	4·03	3·59	1·76	6·46	1·39
MgO	trace	0·03	0·92	2·48	1·73	0·81	1·19	0·40	1·87	1·87	2·34	1·08	2·88	4·10
CaO	0·38	trace	0·05	trace	1·84	2·21	0·04	1·90	3·17	2·09	2·75	3·14	1·40	3·31
Na_2O	0·34	0·56	0·15	0·25	0·52	0·42	1·41	1·76	1·54	2·14	1·68	2·73	2·35	2·07
K_2O	none	0·30	0·87	1·82	3·15	2·43	1·97	1·48	1·92	1·95	3·16	3·02	1·92	2·88
H_2O^+	0·10	0·51	0·43	2·81	0·11	1·06 }	0·02	0·77	0·11	1·25	0·43	1·93	—	0·90
H_2O^-	—	0·08	0·03	1·09	0·05	— }		0·33	0·02	0·15	—	—	—	—
TiO_2	0·21	—	0·52	0·08	0·72	—	0·76	0·14	0·76	0·77	0·74	—	0·80	—
MnO	trace	—	nil	trace	0·09	—	0·01	0·27	0·05	0·50	0·06	—	0·06	—
	100·49	99·06	99·95	100·24	100·36	99·48	100·19	99·66	99·91	99·88	100·20	99·73	100·45	100·59

*A*1, Libyan Desert glass (Univ. Texas Pub. 3945, anal. 65).
*A*2, Granite (marginal variety), Eskdale, England (U.S. Geol. Surv. Prof. Paper 99, 51).
*B*1, Darwin glass (also ZrO_2, 0·11) (Univ. Texas Pub. 3945, anal. 1).
*B*2, Metarhyolite, Shasta Co., Calif. (also S, 0·35; BaO, 0·05) (U.S. Geol. Surv. Prof. Paper 99, 51).
*C*1, Moldavite (Univ. Texas Pub. 3945, anal. 12).
*C*2, Felsite, Co. Waterford, Ireland (U.S. Geol. Surv. Prof. Paper 99, 53).
*D*1, Bediasite (Univ. Texas Pub. 3945, anal. 16).
*D*2, Granite, Settsu, Japan (also P_2O_5, 0·48; ZrO_2, 0·03; S, 0·06) (U.S. Geol. Surv. Prof. Paper 99, 53).
*E*1, Australite (also NiO, 0·06) (Univ. Texas Pub. 3945, anal. 56).
*E*2, Granite, Reefton, New Zealand (also P_2O_5, 0·09; SO_3, 0·08) (U.S. Geol. Surv. Prof. Paper 99, 331).
*F*1, Indochinite (also P_2O_5, 0·14) (Univ. Texas Pub. 3945, anal. 40).
*F*2, Granite, Styria, Austria (U.S. Geol. Surv. Prof. Paper 99, 103).
*G*1, Ivory Coast tektite (Univ. Texas Pub. 3945, anal. 63).
*G*2, Quartz diorite, Corsica (also P_2O_5, 0·20) (U.S. Geol. Surv. Prof. Paper 99, 331).

must have originated by the fusion of sedimentary rocks is unwarranted.

BRIAN MASON
American Museum of Natural History,
New York 24.
Dec. 12.

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Glaciation in the Jammu Hills

MUCH evidence of the last or Pleistocene Ice Age has been observed in various parts of the Central and the Lesser Himalayas. Lieut.-Col. J. L. Grinlinton has referred to the shape of polished and striated or grooved rock surfaces in the Liddar and Sind Valleys of the Kashmir Himalayas[1]. Many terminal moraines have also been noticed on the southern flank of the Pirpanjal at altitudes of somewhat less than 8,900 ft.; but no traces of the Pleistocene glaciation have been so far discovered anywhere in the Jammu Hills south of the Pirpanjal.

My colleague, Mr. T. R. Bhatia, and I recently visited Tringla, close to Batote hill station 78 miles from Jammu. Batote is situated at lat. 33·7° and long. 75·20° at an altitude about 5,000 ft. above sea-level. This hill station and the entire country from Udhampur to Peera and leading to Srinagar, Murree and beyond in West Pakistan, to Teetwal in the north-west and for a considerable distance eastwards is covered by the rocks belonging to the Murree series, of Oligocene and Lower Miocene age.

Our attention was attracted in this series by a few outcrops of the compact and hard sandstone which showed an unusual degree of smoothness. A closer examination of these outcrops revealed a number of grooves, roughly parallel to one another, running in a north–south direction and 5–9 in. long. Evidently these were glacial striæ on the polished sandstone dipping roughly southwards at an angle of about 40°, furnishing convincing proofs of their having been produced by glacial action during the Pleistocene Ice Age. The grooves possessed a virtually original freshness and appeared to have been rubbed off from the neighbouring polished surface. In one sandstone projection a fairly large cut with polished sides was seen. This must have been carved by the silt-charged water when the ice was in the process of melting. Further investigation near the same spot showed a number of large boulders with polished and grooved surfaces. On one of them the grooves were intact, but the polish had completely gone. Similar observations were made about 1 mile to the east towards the Chakou Nala.

In our opinion, the Patni Top area south of Batote, altitude 7,000 ft., served as the gathering ground for the snow and ice during the Pleistocene times and from this snowfield one or more glaciers descended northwards towards Batote. The entire Patni Top area has at present the topography of a big cirque now breached by a couple of small streams.

R. C. MEHDIRATTA
University of Jammu and Kashmir,
Srinagar.
Dec. 1.

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[1] Geol. Surv. Ind., Mem. 49, Pt. 2.

Niobium–Zirconium–Thorium–Uranium and Rare-Earth Minerals from the Pegmatites of South Harris, Outer Hebrides

DURING a recent examination of some of the pegmatites in the Lewisian rocks of South Harris a suite of rare minerals was found which may stimulate further research into the numerous, but somewhat neglected, pegmatite occurrences in other parts of the Lewisian of north-west Scotland.

References to the South Harris pegmatites have been made from time to time[1–4], and Holmes, Shillibeer and Wilson[5] estimated the age of the potash–felspars from the Chiapaval and Roneval pegmatites by the potassium–argon method and found them to be 1,110 ± 70 million years, and 1,140 ± 70 million years, respectively.

In the earlier part of the Second World War, the Chiapaval pegmatite near Northton and the Sletteval pegmatites east of Roneval were opened out and quarried for potash–felspar on a considerable scale. These large quarries attracted our interest, and a search for rare minerals was made.

The Chiapaval pegmatite vein, which stretches for a mile, and in places is up to 80 ft. thick, consists of microcline, albite and quartz, with a subordinate amount of muscovite as the major mica constituent. Of the minor minerals, topaz, beryl, black-tourmaline and garnet have been previously recorded[1,4]; the latter mineral seems to be quite abundant locally and was found to contain some 20 per cent of manganese monoxide. In addition, the following minerals have been found: columbite (approximately 60 per cent of niobium pentoxide), thorite, uraninite, kasolite (a hydrated uranium-lead silicate), a mineral with an X-ray diffraction pattern almost identical with kasolite, but predominantly a thorium-lead silicate, betafite, zircon, monazite, allanite, and gahnite (a zinc-spinel).

No zoning on a large scale is apparent in the Chiapaval pegmatite: on a small scale, however, microcline–albite–quartz zoning does occur. The rare minerals are not confined to any particular zone or paragenesis, and columbite, for example, was observed in association with microcline, albite, muscovite and quartz, and even at times enclosed in the manganese garnet. The association garnet–gahnite–columbite is quite common.

The main Sletteval pegmatite quarries, east of Roneval, were examined in some detail; but apart from apatite no unusual minerals were observed.

A pegmatite north-east of Sletteval, near Loch a' Sgurr, contained numerous magnetite aggregates, associated with a greenish-yellow mica, which were found to be quite radioactive. Laboratory investigation showed that this pegmatite contained uraninite, thorite, monazite, uranophane and epidote, together with metamict zircon and allanite, and minor spessartine and pyrites. Under the binocular microscope, all these minerals can be seen closely associated with the magnetite.

The pegmatites of the area fall into two major groups: (*a*) those with muscovite as the dominant mica; (*b*) those containing biotite mica, magnetite and only minor muscovite, which generally show more radioactivity than the former.

O. VON KNORRING
R. DEARNLEY

Department of Geology,
The University,
Leeds, 2.

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BIOCHEMISTRY and PHYSIOLOGY

Presence of Griseofulvin in Hair of Guinea Pigs after Oral Administration

GENTLES[1] has found that oral administration of griseofulvin to guinea pigs previously infected with either *Microsporum canis* or *Trichophyton mentagrophytes* arrests the progress of the fungal disease and prevents the highly inflammatory reaction normally encountered in untreated animals. Histological examination showed that most of the hair follicles and most of the lower portions of hair-shafts were free from dermatophytes after a few oral doses of the antibiotic. The hyphal tips of the fungi were sometimes malformed and in that way reminiscent of the effect of griseofulvin on other susceptible fungi.

These findings can be explained by postulating that griseofulvin is deposited in the keratinous layer of the epidermis and penetrates into the hair follicle, where it is somehow incorporated into the newly formed keratin of emerging hair-shafts. The latter should thus contain a band of resistant keratin from which it might be possible to recover griseofulvin.

To test this theory, bulked hair from several untreated guinea pigs and from animals that had received 23 consecutive daily oral doses of 30–40 mgm./kgm. were extracted and the purified extracts were subjected to bio-assay against *Alternaria solani*, using a modification (Napier, E. J., and Rhodes, A., personal communication) of the *Botrytis allii* hyphal curling assay[2]. The bio-assays were carried out by Mrs. E. J. Napier, of Glaxo Laboratories Ltd.

Since the bio-assay is affected by the presence of some contaminants, a fairly elaborate purification procedure was used. The animals were kept in individual cages with wire grid bases, to avoid contamination with griseofulvin from urine or fæces, and were closely clipped before treatment, to ensure a high concentration of griseofulvin in the hair. At the end of the treatment, 7·5-gm. portions of hair from treated and untreated animals were washed by stirring for half an hour with 450 ml. water and then similarly stirred and filtered three more times. The first three filtrates (*a*) were combined, (*b*) the fourth was kept separate. The hair was then extracted by refluxing four times for half an hour with 250-ml. portions of methanol. The first three filtrates from these extracts (*c*) were combined and (*d*) the fourth was kept separate. The aqueous filtrates (*a* and *b*) were extracted separately with half-volumes of light petroleum (60°–80° C.). This removes undesirable lipoid matter, but extracts some griseofulvin also, which was recovered by re-extracting the petroleum layers with equal volumes of 50 per cent aqueous methanol. After the methanol had been removed from these phases by distillation under reduced pressure, the aqueous residues were bulked with the corresponding main aqueous fractions, each of which was then extracted with benzene (3 × quarter-volumes). The two benzene extracts were dried over sodium sulphate, concentrated to small bulk under reduced pressure and passed through alumina columns (3*g*, 'Woelm acidic'). Development with benzene (about 200 ml.) having removed further impurities, the griseofulvin was eluted with 1 per cent ethanol in benzene. The eluates were evaporated to dryness under reduced pressure and were then ready for bio-assay.

The two methanolic filtrates (*c* and *d*) were extracted with half-volumes of light petroleum, which was discarded. The methanol solutions were concentrated to small bulk with the addition of water, distillation being continued until all methanol had been removed. The aqueous solutions were extracted with benzene and the benzene extracts processed further, as described above. The results of the eight bio-assays are shown in Table 1.

From 1 gm. hair of the treated animals, between 5 and 6 μgm. griseofulvin were obtained, about half

Table 1. GRISEOFULVIN CONTENT OF GUINEA PIG HAIR

Fraction	Total griseofulvin (μgm.) in 7·5 gm. hair:	
	Control	Treated
a	0	21
b	0	0
c	0	20
d	0	0·8

of it being extractable by cold water. It is not at present clear whether perhaps this portion was excreted through the skin and only adhered to the hair, the other half having been deposited in the hair keratin. Whatever the exact mechanism, it seems fairly certain that the eradication of dermatophytic infections by griseofulvin is due to its incorporation somehow in keratinous tissues.

J. C. GENTLES

Department of Bacteriology,
The University, Glasgow, W.2.

M. J. BARNES
K. H. FANTES

Glaxo Laboratories Ltd.,
Sefton Park, Stoke Poges, Bucks.

[1] Gentles, J. C., *Nature*, **182**, 476 (1958).
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Effects of Deficiency of Pantothenic Acid on Oxygen Poisoning in the Rat

IT has been known for many years[1] that a close connexion exists between pantothenic acid and the suprarenal glands, atrophy of which may result from a deficiency of pantothenic acid. More recently, Hurley and Morgan[2], arguing that animals in the final stages of pantothenic acid deficiency should behave as though adrenalectomized, showed that rats on such a diet were less resistant to the stress of anoxia than were normal controls.

It has, however, been shown that when the 'stress' is exposure to pure oxygen under high pressure, adrenalectomized rats fare better than do normal animals[3–5]. I found[6] that the variability in the time of appearance of nervous system effects in oxygen poisoning was very great in adrenalectomized rats and could not be correlated with the presence of small amounts of residual cortical tissue. Since it seemed reasonable to assume that a dietary deficiency would affect all susceptible tissue, irrespective of its site in the body, it followed that a pantothenic acid deficiency might well dispose of aberrant cortical tissue in a way that operation could never do. If such deficient animals were at least as resistant as operated animals and showed less variability of response, the result would tend to confirm the hypothesis that in operated animals the variability was in fact due to aberrant cortical tissue.

A series of experiments was carried out to test the effects of exposure to pure oxygen under a pressure of 6 atm. on rats reared on a pantothenic acid-deficient diet. Eight litters of eight rats, four of each sex, were used. The basic diet was that already described by me[7]. Appropriate vitamin supplements other than pantothenic acid were added to it, and it was fed to the mothers from 12 days before weaning. On weaning, the young rats were divided into 4 groups as follows: *A*, rats fed the deficient diet *ad lib.*; *B*, rats given the basic diet with vitamin supplements, including pantothenic acid (that is, the control diet), and pair-fed within litters with those of *A*; *C*, rats from which both adrenals were removed four days before exposure to oxygen and fed the control diet *ad lib.*; *D*, rats fed the control diet *ad lib.*

At the age of approximately 8 weeks the rats were exposed to oxygen under 6 atm. in a way already described[6]. Four male and two female rats in group *A* died before exposure to oxygen.

The mean times to the onset of severe poisoning, with standard errors, were, for the four groups, as follows: *A*, 49·75 ± 4·46 min.; *B*, 37·50 ± 1·94 min.; *C*, 45·12 ± 2·78 min.; *D*, 30·50 ± 1·09 min. Both the deficient and the operated rats (*A* and *C*) were more resistant than groups *B* and *D*, although, of these, the pair-fed rats *B* were more resistant than the controls fed *ad lib.* (*D*). There was no significant difference in resistance between groups *A* and *C*. Groups *A* and *C* were more variable than group *B*, itself more variable than the controls fed *ad lib.* (*D*).

The effects of pantothenic acid deficiency on oxygen poisoning thus resemble those of adrenalectomy. The problem of the variability of response in these animals remains unsolved. That the diet was effective was shown by the six deaths, by greying of the fur and by the relative failure of the rats to grow; but there was no evidence that time to onset of severe poisoning was related to body-weight. There was no relationship between weight of suprarenal tissue and time to onset of severe poisoning in group *A*, but three of the four most resistant animals had glands which were obviously hæmorrhagic. It is not clear how to determine precisely, in terms of cortical function, the response of individual rats to the pantothenic acid-deficient diet, and thus one source of variability may have been substituted for another. Or it may be that the variability is due to a highly complex relationship between suprarenal cortical function and response to exposure to oxygen under high pressure.

I am indebted to Mr. R. M. Cormack of the Department of Statistics, University of Aberdeen, for help in the design and analysis of the experiments.

D. W. TAYLOR

Department of Physiology,
Marischal College, Aberdeen.
Nov. 10.

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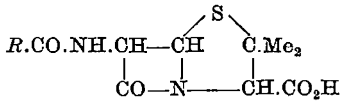
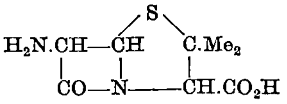
Synthesis of Penicillin : 6-Aminopenicillanic Acid in Penicillin Fermentations

THE work reported here stemmed from the experiments described in an earlier communication[1] on *p*-aminobenzylpenicillin, in which discrepancies were observed between chemical and biological methods of penicillin assay when a precursor was omitted from penicillin fermentations.

The various penicillins (formula I) may all be regarded as acyl derivatives of a common parent amine, 6-amino-penicillanic acid (formula II: for nomenclature see Sheehan *et al.*[2]). We wish to report the isolation of pure 6-amino-penicillanic acid from penicillin fermentations carried out in the absence of added side-chain precursor, the culture used being an isolate from *Penicillium chrysogenum* *W*.51.20.



(I)



(II)

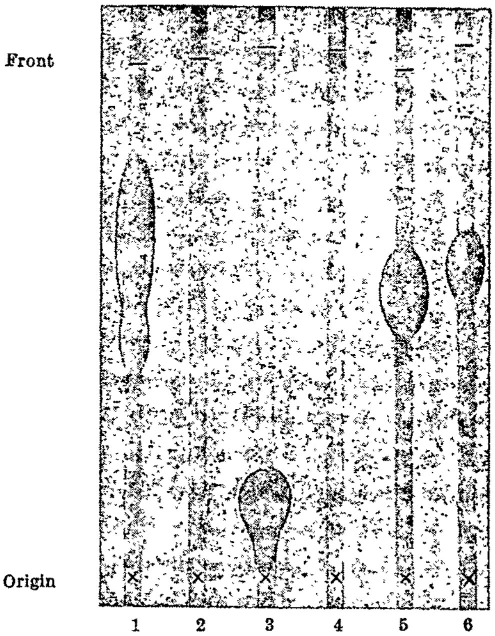


Fig. 1. Chromatograms of fermentation liquors. 1, Filtrate of fermentation carried out in the absence of side-chain precursors; 2, filtrate as (1) after extraction with butyl acetate at *p*H 2·0; 3, as (2) but the chromatogram sprayed with aqueous sodium bicarbonate and an acetone solution of phenylacetyl chloride before developing on the seeded agar plate; 4, solvent-extracted filtrate as (2) treated with penicillinase before chromatography and then sprayed with the solutions of sodium bicarbonate and phenylacetyl chloride as in (3); 5, solvent-extracted filtrate, as (2), treated with sodium bicarbonate and phenylacetyl chloride before chromatography; 6, penicillin *G*. Solvent: butanol/ethanol/water, 40 : 10 : 50, top layer; Whatman No. 1, running time 15 hr.

The presence of (II) was first indicated when such a fermentation liquor, after removal of natural penicillins by solvent extraction at low *p*H, was treated with an excess of phenylacetyl chloride in the presence of a weak base such as sodium bicarbonate. This resulted in the formation of an antibiotic substance which was readily destroyed by penicillinase and which behaved similarly to penicillin *G* on paper chromatograms. Similarly, reaction with phenoxyacetyl chloride resulted in the formation of an antibiotic resembling pencillin *V* in its stability in acid solution as well as its behaviour on paper chromatograms. The reaction with phenylacetyl chloride in the presence of sodium bicarbonate was readily adapted to the detection of (II) on paper chromatograms (Fig. 1) which were sprayed with the appropriate reagents before plating on agar seeded with a sensitive bacterium in the usual way. This conversion of (II) to benzylpenicillin on paper strips also provided a convenient method of assay, being similar to the well-known paper disk method.

Pure crystalline 6-aminopenicillanic acid, details of the isolation of which will be reported at a later date, had m.p. 208–209° C. (decomp.) (found: C, 44·6; H, 5·7; N, 13·1; S, 14·1 per cent; $C_8H_{12}O_3N_2S$ requires C, 44·4; H, 5·6; N, 13·0; S, 14·8 per cent). Phenylacetylation and subsequent biological assay on paper as outlined above gave 2,740 units of benzylpenicillin per mgm. of starting material (theory 2,752 units/mgm.). 6-Aminopenicillanic acid itself possesses definite antibacterial properties, but these are mostly of a much lower order than those of benzylpenicillin, and the spectrum is of a different type. It is destroyed by penicillinase (*Bacillus cereus* broth filtrate) but at a much slower rate than is benzylpenicillin. Like the penicillins it is rapidly decomposed by strong alkali, but as would be expected from its structural inability to undergo rearrangement to a penillic acid, it is relatively stable to acids. The compound is itself a surprisingly strong acid, the isoelectric point being about 4·3.

Chemical evidence supporting the structure (II) has been obtained by treatment of the substance with ethyl chloroformate to give a crude N-carbethoxy derivative (I; R = EtO) which was degraded by the general method of Dutcher *et al.*[3] to N-carbethoxyaminoacetaldehyde 2 : 4-dinitrophenylhydrazone (51 per cent overall yield), bright yellow micro-needles from alcohol, m.p. 174–175° C., not depressed by admixture with a specimen synthesized from aminoacetal (found: C, 42·2; H, 4·2 per cent; $C_{11}H_{13}O_6N_5$ requires C, 42·4; H, 4·2 per cent).

Furthermore, the benzylpenicillin which had been prepared by phenylacetylation of (II) was isolated as the N : N′-dibenzylethylenediamine salt, which after crystallization from acetone had m.p. 114–115° C., not depressed by admixture with an authentic specimen[4] (found: C, 59·4; H, 6·8; N, 9·0; S, 6·5 per cent; calc. for $C_{48}H_{56}O_8N_6S_2.3H_2O$: C, 59·8; H, 6·5; N, 8·7; S, 6·7 per cent). A portion of this same phenylacetylation product was degraded to benzylpenilloaldehyde, which was isolated as the 2 : 4-dinitrophenylhydrazone, m.p. 196° C., not depressed by admixture with an authentic specimen[3].

Various authors have expressed the view that the last stage in penicillin biosynthesis is the introduction of the acyl side-chain[5]. Our isolation of 6-aminopenicillanic acid is consistent with this view, but does not preclude the possibility of it arising during fermentation, either as an alternative metabolite or by enzymatic hydrolysis of a penicillin[6]. The substance is nevertheless a most useful chemical intermediate for the preparation of new penicillins and related compounds which are not easily accessible in other ways. The possible therapeutic usefulness of such derivatives is being investigated in these Laboratories (patent application pending, 1957).

We wish to thank Prof. E. B. Chain, Dr. A. H. Cook and Sir Ian Heilbron for helpful discussions and the Directors of Beecham Research Laboratories for permission to publish this communication.

F. R. Batchelor
F. P. Doyle
J. H. C. Nayler
G. N. Rolinson

Beecham Research Laboratories, Ltd.,
Brockham Park,
Betchworth,
Surrey.
Nov. 26.

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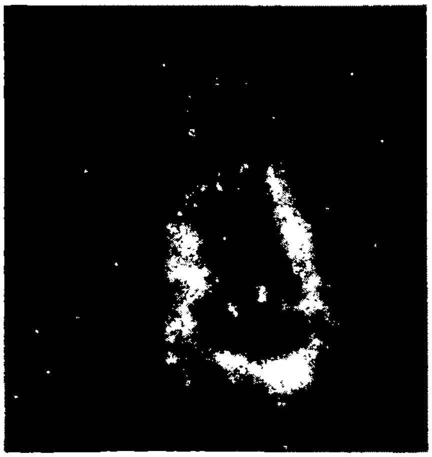

Fig. 2. 8-μ cold microtome section of mouse kidney, 18 hr. after intraperitoneal injection of ovalbumin labelled with a fluorescent dichloro-triazinyl dye. (× 1,100)

The labelling of proteins with reactive dyes is simple and offers considerable advantages over current methods of conjugating proteins through azo[5] and ureido[6] linkages. In a series of preliminary tests with fluorescent or coloured dyes containing other reactive groups (sulphon-β-chloroethylamide, sulphon fluoride, thiocyano, chloroacetylamino, γ-chloro- β-hydroxy-propyl) the superiority of the dichloro-triazinyl group appears to be established. These studies are being continued and extended.

R. Hess
A. G. E. Pearse

Postgraduate Medical School of London,
Du Cane Road, London, W.12.
Dec. 19.

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Reversal of Antibiotic Action of Cycloheximide (Actidione) by Bivalent Metal Ions

Cycloheximide, an antibiotic with selective inhibitory effect on many fungi[1,2] but inactive against bacteria, has received increased attention during recent years, but few reports are concerned with its mode of action. Cycloheximide inhibits aerobic utilization of many intermediates of carbohydrate metabolism by *Tetrahymena pyriformis*[3], and it is active against higher plants[4]. Kerridge[5] has observed that fungistatic doses of cycloheximide (0·5–1·0 μgm./ml.) have no marked effect on fermentation and respiration of *Saccharomyces mandshuricus*, but synthesis of protein and deoxyribonucleic acid is completely blocked. On the other hand, Greig *et al.*[6] have recently announced that in the case of *Saccharomyces cerevisiae* the same antibiotic shows an inhibitory effect on fermentation.

This communication presents the results of a study of the inhibitory action of cycloheximide on growth and respiration of a sensitive strain of *Candida krusei* and a resistant strain of *Candida albicans*. Previous authors employed agar plate techniques for measurement of growth; in the present work growth was estimated turbidimetrically. Cultures were incubated for 22 hr. with forced aeration at 28° C. in a liquid medium containing glucose and mineral salts.

The results of experiments on growth show that 0·5 μgm./ml. of cycloheximide has a marked antibiotic effect while 2 μgm./ml. inhibit completely the multiplication of *C. krusei*. The growth of the resistant *C. albicans* was not altered by concentrations of antibiotic up to 100 μgm./ml. The activity of antibiotic remained unchanged when ammonium sulphate in the medium was replaced by other nitrogen sources, such as amino-acids, peptides and protein hydrolysates. Curiously enough, the only exception was peptone which, in a concentration of 1 per cent, almost completely suppressed the inhibitory action of cycloheximide. The degree of inhibition depended on the origin of the peptone employed and was due not to the organic components but to iron. When the heavy metals in peptone were precipitated by hydrogen sulphide the reversal of inhibition did not occur; when ferrous iron alone was added to the mineral medium with inorganic source of nitrogen, the inhibitory effect of cycloheximide was suppressed.

The reversal of inhibitory activity was also demonstrated in manometric experiments with washed suspensions of *C. krusei*. Cycloheximide at a concentration of 0·5 μgm./ml. caused 40 per cent inhibition of the rate of oxidation of glucose by intact cells. In the presence of 2×10^{-4} *M* $FeSO_4.7H_2O$ and 0·5 μgm./ml. of cycloheximide the respiration was even faster than in the control without antibiotic. Manganese or zinc, like iron, antagonized the inhibitory effect of antibiotic; calcium, magnesium or cadmium were less active and copper had no detectable effect. Respiratory activity of washed cells of *C. albicans* was not influenced by cycloheximide.

These observations suggest that cycloheximide forms chelates with bivalent metals and that these complexes are antibiotically inactive. This phenomenon of chelate formation is not unique among antibiotics, and the subject has been well summarized in a review by Weinberg[7]. He, as well as Whiffen[2], did not report any influence of metals in the case of cycloheximide; but Greig *et al.*[6] observed potentiation of the inhibitory effect of this antibiotic on fermentation by *Saccharomyces cerevisiae*. This apparent discrepancy concerning the mode of action of metals on antibiotic potency of cycloheximide seems to be due not only to the use of different organisms but also to different criteria and methods employed.

Details of these experiments will be published elsewhere.

M. Blumauerová
J. Stárka

Department of Microbiology,
Faculty of Biology,
Charles University,
Prague, 2.
Nov. 14.

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Determination of Nitrogen in Proteins by means of Indanetrione Hydrate

THE determination of nitrogen in organic substances has been performed by either of the well-established methods, namely, one attributed to Dumas or the other first described by Kjeldahl. These methods require approximately 300 μgm. of nitrogen for accurate determination. The method to be described requires much less material, and compares favourably in accuracy with these standard methods. The sample is decomposed by digestion in sulphuric acid, and the ammonia is determined quantitatively by means of indanetrione hydrate.

The sample (for example, 0·05–0·10 ml. serum) is digested in 0·5–1·0 ml. sulphuric acid to which is added 3–5 mgm. of a mixture of copper sulphate (microanalytical reagent), potassium sulphate (microanalytical reagent), mercuric oxide (laboratory grade) and selenium (5 : 15 : 5 : 1 parts by weight respectively). The sample is heated in a standard Kjeldahl flask for 45 min., when it should have cleared. If the acid digest is not clear after 45 min., the flask is cooled, 0·2 ml. of hydrogen peroxide solution (100 vol. B.D.H., microanalytical reagent) is added drop by drop and the contents of the flask are re-heated. The solution becomes clear immediately and the heating is continued for 2 hr.

The digested sample is dissolved in 0·4 M sodium citrate buffer solution pH 5·0 (25 ml. buffer solution for 0·5 ml. sulphuric acid : 50 ml. buffer solution for 1·0 ml. sulphuric acid). An aliquot, normally 0·5 ml., of this solution, diluted further if necessary with buffer solution to make 2·0 ml., is mixed with 2·0 ml. of a 2 per cent indanetrione hydrate solution. (2·0 gm. indanetrione hydrate : 50 ml. methyl 'Cellosolve' : 25 ml. 4·0 M sodium acetate buffer solution pH 5·5 (544 gm. sodium acetate trihydrate + 100 ml. glacial acetic acid per litre) : 25 ml. water : 0·08 gm. stannous chloride dihydrate (analytical reagent).) The mixture is heated in a water bath at 100° C. for 30 min., cooled and diluted with 6 ml. of a solution of ethanol/water (1 : 1 by volume).

When determined in a Uvispek spectrophotometer, a solution containing 0·4 μM of ammonia (= 5·6 μgm. nitrogen) has an optical density of 0·805 (±0·008) for 1 cm. path-length at a wave-length of 570 mμ. The optical density of the control solution, that is, 1·0 ml. sulphuric acid (microanalytical reagent) diluted in the same manner, varies between 0·045 and 0·060.

Column 1 of Table 1 shows typical analyses of a serum from a normal rhesus monkey performed by the indanetrione hydrate method. Column 2 shows analyses of the same serum by the standard micro-Kjeldahl method.

Table 1

Indanetrione hydrate	Micro-Kjeldahl
11·3 mgm. N per ml.	11·3 mgm. N per ml.
11·3	11·4
11·4	11·3

The method has been used for routine purposes and is found to be more reliable than the standard micro-Kjeldahl method. The aliquot, examined in triplicate if necessary, contains only one-fiftieth or one-hundredth part of the original nitrogen. Work is in progress to apply this method to the quantitative determination of nitrogen in other nitrogenous compounds following their digestion in sulphuric acid.

The indanetrione hydrate may be purified without loss by the method already described[1]. The presence of traces of cations in the digest solution, due to the catalyst, does not affect the colour development (cf. Meyer and Riklis[2]) during the reaction between the ammonia and the indanetrione hydrate. Wherever possible, analytical reagents are used and all solutions are prepared with conductivity water obtained by de-ionizing once-distilled water[3]. In our experience the analytical reagent most likely to produce high values of optical density with the control solution is sodium acetate: but this compound may be easily purified by re-crystallization from ethyl alcohol to yield satisfactory values of optical density with the control solution.

S. JACOBS

National Institute for Medical Research,
Mill Hill, London, N.W.7.

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Replacement of Thiamine as a Growth Factor for *Mycobacterium butyricum*

THIAMINE is recognized as a growth factor for many micro-organisms. Some micro-organisms require the presence of the whole thiamine molecule whereas others are able to synthesize either the pyrimidine or thiazole moieties. In some instances, cells are unable to use either component, but if supplied with the two fragments can combine the two into the complete molecule. Pyrithiamine (1-[(4-amino-2-methyl)-5-pyrimidylmethyl]-2-methyl-3 (α-hydroxyethyl) pyridinium bromide) is a thiamine analogue in which a pyridine ring replaces the thiazole moiety. This analogue has an anti-thiamine effect in some micro-organisms, and in others it can replace thiamine by acting as a source of the pyrimidine ring[1,2].

Thiamine is required for the growth of *Mycobacterium butyricum* in chemically defined media[3]. This requirement has been examined by growing *M. butyricum* (No. 337, National Collection of Type Cultures, Lister Institute, London) on a synthetic medium containing inorganic salts with glycerol as a carbon source and ammonium sulphate as a nitrogen source. To this medium was added thiamine hydrochloride, 4-amino-5-aminomethyl 2-methyl pyrimidine 2 hydrochloride, 5-(2-hydroxyethyl) 4-methyl thiazole, or pyrithiamine. The medium was sterilized by autoclaving at 15 lb. for 15 min. The flasks (500 ml.) containing 100 ml. of medium were inoculated with a washed suspension of cells (0·4 mgm. dry wt.) and the cultures incubated aerobically at 38° for nine days. Growth was estimated by filtering off the cells, washing well with distilled water and drying at 105° in weighed crucibles.

Only a slight growth was observed in the absence of thiamine or with the thiazole fragment (Table 1). Good growth occurred with thiamine, with the pyrimidine moiety, with the pyrimidine plus thiazole moieties, or with pyrithiamine. Since the pyrimidine fragment seems to be essential for growth, it was considered possible that pyrithiamine was exerting its effect due to hydrolysis on autoclaving. This was tested by adding to the growth medium pyrithiamine sterilized by autoclaving or by filtering through a glass filter (porosity 5), or by adding directly from its bottle to the sterile medium. No difference was noted in the growth response to autoclaved, filtered or unsterilized pyrithiamine.

These results demonstrate the inability of *M. butyricum* to synthesize the pyrimidine moiety of thiamine at a sufficient rate to promote normal

Table 1. THE REPLACEMENT OF THIAMINE AS A GROWTH FACTOR FOR *Mycobacterium butyricum*

Addition to medium	Concentration of addition (μgm./100 ml.)	Bacterial growth (mgm. dry weight)
No addition	—	20
Thiamine	200	114
Thiamine	1,000	119
Pyrimidine fragment	100	101
Pyrimidine fragment	500	106
Thiazole fragment	100	20
Thiazole fragment	500	24
Pyrimidine plus thiazole fragments	100 500	102 110
Pyrithiamine	200	117
Pyrithiamine	1,000	122

growth. Presumably the bacteria can split pyrithiamine and utilize the pyrimidine portion. Martin[4] has reported similar findings with *Nocardia corallina*, an organism related to the *Mycobacteria*, and Lutz[5,6] has shown that the thiamine requirement of *M. phlei* and *M. paratuberculosis* could be replaced by the pyrimidine moiety for the former and by the pyrimidine moiety or pyrithiamine for the latter organism.

D. E. WRIGHT

Biochemistry Department,
Medical School,
University of Otago,
Dunedin,
New Zealand.
Oct. 20.

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Aminopeptidase Activity in Cancer Cells

THE enzyme, aminopeptidase, was included in an investigation on histochemically demonstrable enzyme activities in human pathological lesions. This enzyme was demonstrated by Burstone's method[1] except that cryostat sections were used which were fixed for 5 min. in acetone.

Some observations on aminopeptidase activity in tumours have appeared[2,3]. The authors of these publications mention the high aminopeptidase activity in the stroma around invading tumour cells; but they saw only little activity in the tumour cells.

At present, we have investigated the aminopeptidase activity in about sixty human neoplasms, surgically removed. We can confirm the observations on aminopeptidase activity in some parts of the stroma around the tumour cells. This was especially the case in epidermoid carcinoma, for example, of the lung (eight cases). However, the most striking observation we made was the very high aminopeptidase activity in the tumour cells in each of four cases of gastric carcinoma and in two cases of carcinoma of the bile ducts. After a very short incubation (5 min.) of the acetone-fixed sections in the substrate, activity was demonstrated by the brilliant red coloration developed.

The gastric carcinomas were of different types. The first case was an anaplastic carcinoma of the stomach with metastases in the regional lymph nodes. In the sinus of these lymph nodes many tumour cells of the signet cell type could be seen. In the anaplastic cells of the primary tumour as well as in the signet cells of the lymph nodes a high aminopeptidase activity was observed (Fig. 1).

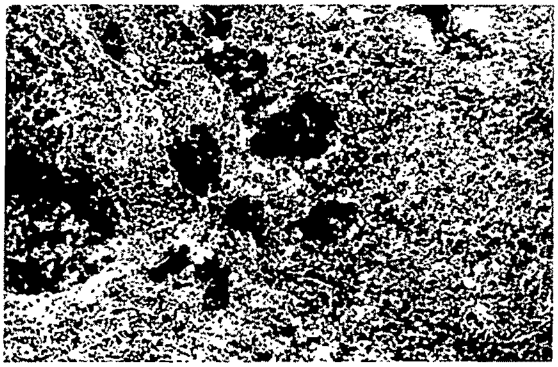

Fig. 1. Groups of signet cells in a lymph node with a high aminopeptidase activity

In the second operation specimen a well-differentiated adenocarcinoma infiltrated the muscle layers of the stomach wall. These tumour cells all showed high aminopeptidase activity in their luminal borders (Fig. 2).

In the third case of a poorly differentiated adenocarcinoma, we observed a high aminopeptidase activity throughout the protoplasm of many tumour cells.

The fourth gastric carcinoma was obtained from an autopsy. In the stomach an ulcerating carcinoma was found, about 2 cm. in diameter. In the lymph nodes the tumour cells showed high enzyme activity.

In some cases of atrophic gastritis combined with a peptic ulcer the epithelial cells show no aminopeptidase activity except for some islands of positive cells of the surface epithelium and in the crypts. These islands are more numerous in the prepyloric region, while in the duodenum and small intestine all epithelial cells show a high aminopeptidase activity along their luminal border.

In a peptic ulcer, aminopeptidase activity was only seen in the granulation tissue of the bottom.

In a normal human stomach no enzyme activity was found in the epithelial cells. In normal lymph nodes and in lymph nodes with proliferation of the reticulum cells only some scattered reticulum cells with aminopeptidase activity were seen. This activity is not as high as in the cells of the gastric cancer; moreover, no groups of positive cells were seen in these lymph nodes.

Both carcinomas of the bile duct were of the anaplastic type. Most of the tumour cells stood out clearly by their high enzyme activity. In the

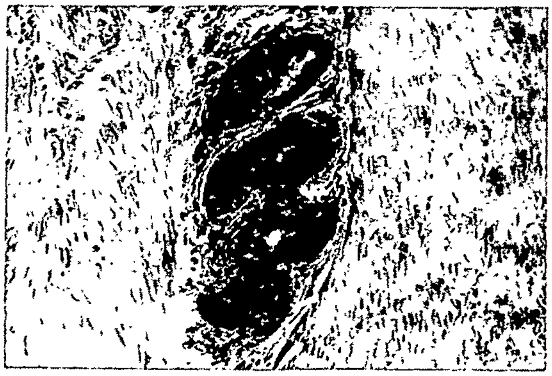

Fig. 2. Aminopeptidase activity in luminal border of tumour cells of an adenocarcinoma

normal epithelium of the human gall bladder and bile ducts there is high aminopeptidase activity in the luminal borders of the cells. Hitherto none of the other tumours has shown aminopeptidase activity.

On the basis of these observations we think that it is worth while to apply this histochemical method for aminopeptidase activity in fresh surgical specimens: (1) in lymph node biopsies with metastatic tumour cells, to investigate the possibility of gastric or bile duct origin; (2) during operations for gastric and bile duct carcinoma, to detect tumour cells in regional lymph nodes and surgical margins.

R. G. J. Willighagen
H. T. Planteydt

Pathological Laboratory,
University of Leyden.
Nov. 12.

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Recording Inhibition and Excitation in the Cat's Retinal Ganglion Cells with Intracellular Electrodes

In the light-adapted state, the receptive fields of retinal ganglion cells in the cat consist of excitatory and inhibitory areas. Thus predominantly excitatory and inhibitory pathways converging on a ganglion cell can be stimulated selectively[1] and thereby the mechanism of excitation and inhibition can be studied. It has recently become possible to record from retinal ganglion cells with intracellular leads for short periods[2]. In the present study, penetrations into cells were fairly frequent; but most cells gave injury discharges and their membrane potentials declined within several minutes. However, intracellular records from some ganglion cells were recorded with stable membrane potentials of 50–70 mV. for as long as 20 min. Discharge patterns were similar to those obtained during extracellular recordings.

The following typical changes were seen in the membrane potential and in the discharge patterns of ganglion cells in the light-adapted state. If in an 'on'-centre receptive field a light spot was shone in the centre of the field, a maintained graded depolarization was set up, accompanied by an increase in frequency of impulses (Fig. 1*A*). The magnitude of the maintained depolarization as well as the discharge-rate were graded according to the strength of illumination. When the light was turned off the membrane potential and discharge frequency gradually returned to original levels. If an annular-type stimulus was used, throwing light only on the outer portion of the same receptive field, the maintained background activity was suppressed. At the same time the membrane potential of the cell was increased (Fig. 1*B*). As the light was turned off, there was a further increase of the membrane potential, followed by depolarization and an off discharge. In Fig. 1*C* the entire receptive field was illuminated, resulting in an interaction between the excitatory and inhibitory portions. The excitatory component predominated, but was much less effective than if the centre alone (as in Fig. 1*A*) was illuminated. Thus stimulation of the entire receptive field caused less impulse activity and less membrane depolarization than illumination of the central portion alone. A marked increase in membrane potential and inhibition of impulse activity occurred as the light stimulus was turned off.

Quite frequently an impaled ganglion cell stopped firing impulses a few minutes after penetration, presumably due to injury by the electrode. But the maintained decrease or increase in the membrane potential could still be observed with appropriate illumination, indicating that these slow potential changes were not dependent on the propagated impulse mechanism.

A few intracellular recordings were obtained from the retinal, presumably unmyelinated, portion of axons of ganglion cells. Membrane potentials were near 50 mV., and the axons were identified by the following criteria. The centre of the receptive field

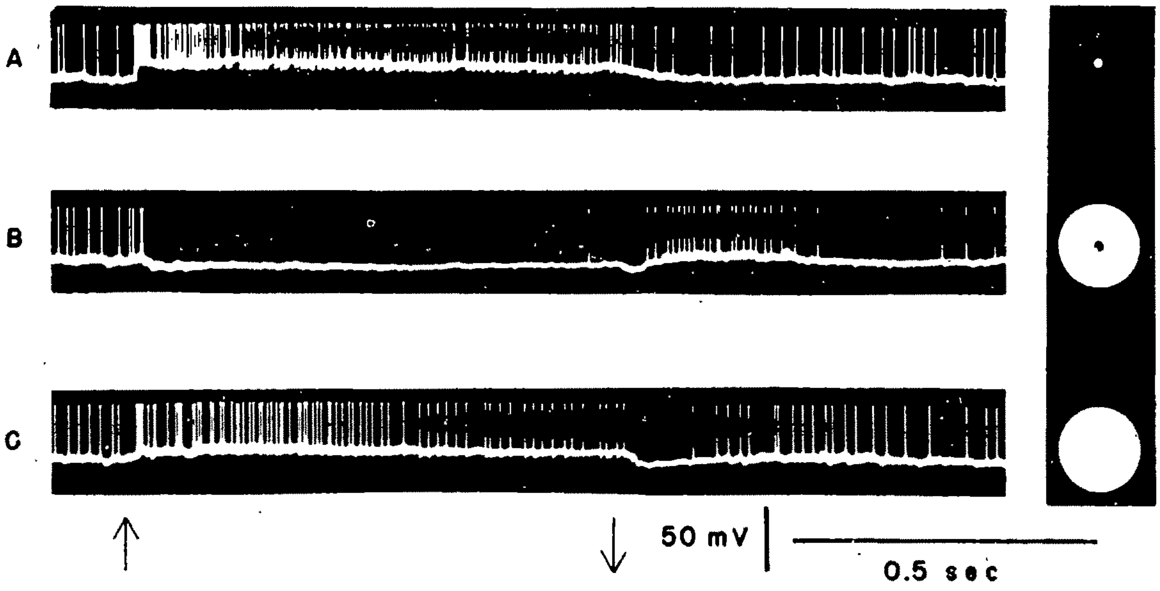

Fig. 1. Intracellular recording from retinal ganglion cell. Membrane potential about 65 mV. Period of illumination marked by arrows. Right, illuminated area marked white. *A*, small light spot of 1° (0·25 mm.) diameter; *B*, annular stimulus, outer diameter 12° (3 mm.) (central area of 1° is not illuminated); *C*, entire receptive field illuminated. Background illumination 0·34 log m.c. Stimulus intensity about 1·85 log m.c.

of such a fibre was some distance from the electrode tip toward the periphery of the retina. The typical slow changes of ganglion cells were absent, the potentials rose sharply and were all or none. Further, there was no sign of synaptic noise which was always present in ganglion cells.

The present observations may be compared with those in a variety of nerve cells. Thus, Eyzaguirre and Kuffler[3], recording from the cell body of the stretch receptor of crayfish, showed corresponding excitatory and inhibitory changes which determined the discharge frequency. Further, Hartline, MacNichol and Wagner[4] and Fuortes[5], leading from the eccentric cell in the *Limulus* eye, described a similar graded depolarization during illumination which was directly related to the discharge frequency. Corresponding slow potentials, both with excitation and inhibition, have been reported by Kolmodin and Skoglund[6] in the motoneurons and interneurons of the cat's spinal cord. The cortical cells studied by Phillips[7] also had similar slow potentials.

The retinal ganglion cells are the final points of convergence from the neuronal network of the receptive fields, which can extend over an area up to several mm. in diameter. The cells can integrate the excitatory and inhibitory synaptic influences in terms of slow changes in their membrane potential. Presumably, these in turn control the discharge frequencies of the optic nerve fibres.

TORSTEN N. WIESEL

Wilmer Institute,
Johns Hopkins Medical School,
Baltimore, 5.
Nov. 11.

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Bacterial and Testicular Hyaluronidase

IN papers from this laboratory, the actions on dermal connective tissue[1,2] and on ocular structures[3,4] of different kinds of hyaluronidase have been studied. In these experiments, 'Hyason', manufactured by Organon, Oss, Holland, was used as a source of staphylococcal hyaluronidase. This is also preparation *D* of Chauncey *et al.*[5].

We have recently been informed that batches of 'Hyason' released after January 29, 1958, contain testicular instead of bacterial hyaluronidase and we write this communication in order to prevent confusion arising from the change in composition. The manufacturer keeps a stock of the old preparation, and samples are available for research purposes.

ERNST BÁRÁNY
LENNART BERGGREN
LENNART JUHLIN

Pharmacological Institute,
University of Uppsala.
Dec. 1.

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Excitation of the Squid Axon Membrane in Isosmotic Potassium Chloride

THE interesting recent findings in the frog node of Ranvier of an 'action potential' in isosmotic potassium chloride by Müeller[1], and of two stable states in 20–40 m*M* potassium chloride by Stämpfli[2], raise the question as to whether or not similar phenomena are to be found in the squid axon membrane.

I have made a preliminary study of the approximate steady-stage voltage-current relationship for the squid (*Loligo pealii*) giant axon membrane in 0·5 *M* potassium chloride. When the potential was controlled ('*E*-LOC') and varied, a continuous variation of the current is found, including a negative resistance region. The characteristic shape seen in Fig. 1 is typical, although there are some minor variations in the *E–I* curves depending upon the previous potential history and the rate and direction of sweeping. When the current was controlled ('*I*-LOC') and varied the voltage showed the hysteresis loop to be expected about the unstable negative resistance region. This is in complete agreement with Segal's[3] recent finding of two stable potentials for the squid axon membrane in high potassium under current control.

Franck[4] has compiled examples of dynode type characteristics with a negative resistance region which give excitation phenomena. The squid axon membrane in sea water with normal sodium concentration exhibits such a characteristic[5] and gives a normal action potential. Thus, it would also be expected that the squid axon in 0·5 *M* potassium chloride with a similar but displaced characteristic should exhibit excitation under the proper conditions. If the membrane is subjected to a constant hyperpolarizing current, an 'excitation' threshold for superimposed depolarizing current pulses should be found when the net current is less than about 0·15 m.amp./cm.². Fig. 2 demonstrates the threshold and also shows a recovery so that the process may well be called an 'action potential'.

At present, the description of the processes involved in the 'action potential' in 0·5 *M* potassium chloride seems to be as follows: If the squid axon

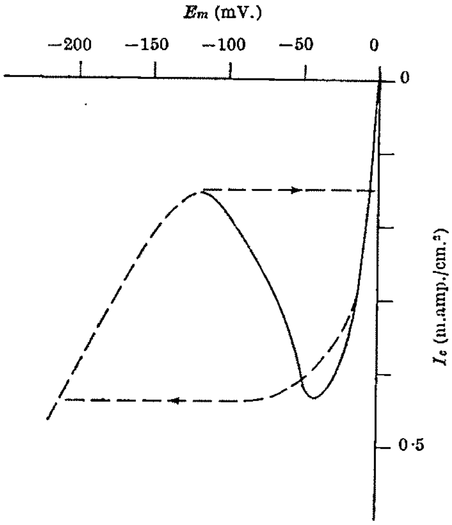

Fig. 1. Voltage-current characteristics of the squid axon membrane in 0·5 *M* potassium chloride. The continuous line was obtained with potential control; the dashed sections with current control. Arrow heads indicate abrupt changes

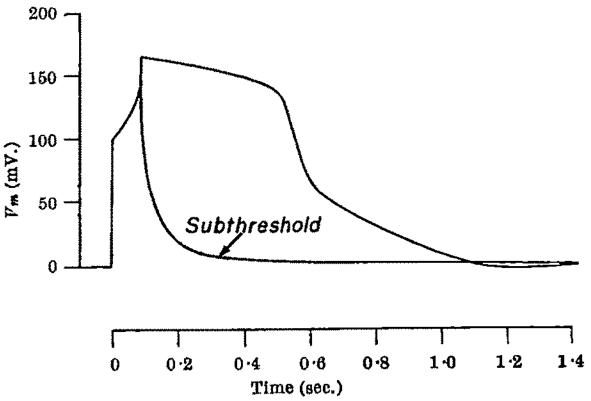

Fig. 2. Time course of an 'action potential' in 0·5 *M* potassium chloride. The membrane was subjected to a constant hyperpolarizing current; additive depolarizing current pulses of about 0·1 sec. of slightly different magnitudes show a threshold

membrane is held near point *A* (in Fig. 3) with a hyperpolarizing current, a pulse of depolarizing current takes the potential up and then along the dashed path at low current; when the pulse is turned off, the membrane potential moves down the right-hand branch of the curve to point *B*. The potential remains in this vicinity until the peak *C* is reduced below the value of the steady current. The potential will then drop back rapidly to point *A*. A possible reason for the shift in the characteristic *E–I* curve and decrease in the peak at *C* is the decrease in potassium concentration in the 'Frankenhaeuser–Hodgkin[6] space' just outside the active membrane. The right-hand branch of the curve through the origin is the characteristic to be expected from 0·5 *M* potassium ion on the Hodgkin–Huxley formulation[7]. The left branch through *A* is probably dominated by the chloride ion conductivity.

The similarities of the frog node[1,8] and squid axon in both normal physiological solutions and isosmotic potassium chloride is highly suggestive of the possibility that similar characteristics are to be found for other excitable membranes with either these or other ions. Outstanding possibilities are chloride ions for *Chara*[9] and barium and strontium ions for crustacean muscle[10].

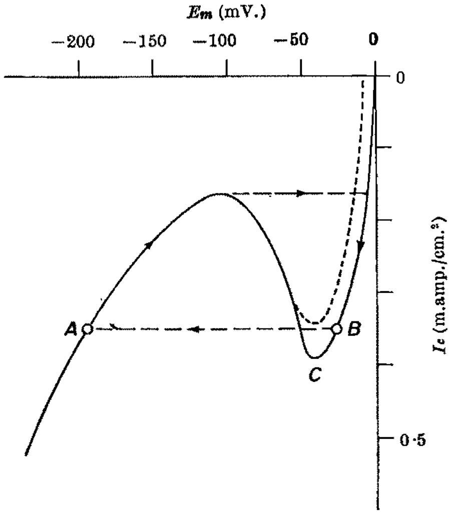

Fig. 3. Trajectories in voltage-current plane which generate an 'action potential'. The dotted line indicates the modification of the branch through the origin when the system remains near the state *B* for about 0·5 sec.

I should like to express appreciation for the co-operation of Drs. K. S. Cole, J. del Castillo and R. E. Taylor in this work, and to the Marine Biological Laboratory, Woods Hole, Massachusetts, for the facilities which made this work possible.

JOHN W. MOORE

National Institutes of Health,
Bethesda, Maryland.

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Influence of Temperature and Light on Reproduction in Male Rats

LIGHT has been considered a gonad-stimulating factor[1], which most probably induces its effect via the pituitary in some animals[2]. It has been reported, though, that some animals respond to light only at a certain season of the year and are refractory to it at other seasons[3]. Autumn breeders, on the other hand, as the goat and sheep, breed at the time of diminishing light[4]. This difference could probably be due to variations in environmental temperature. Another point is that light experiments have usually been done with female animals and with birds. The present investigation was planned to study the effects of temperature and light on reproductive performance in male rats.

Forty-eight mature male rats weighing 180–200 gm. were used. They were divided into six groups of eight animals each. Three groups were kept at the temperature of 18 ± 1° C. and the other three groups were kept at 35 ± 1° C.. Of the groups of animals at each of the two experimental temperatures one was exposed continuously to light of a strength of 30 ft.-candles, another group confined to darkness and the third exposed to 12 hr. of light alternating with 12 hr. of darkness. After 12 days the animals were killed by decapitation under light ether anæsthesia. Their blood was collected, allowed to clot and the serum was obtained by centrifugation at 3,000 r.p.m. for 15 min. The serum was kept in the deep freeze until use. The testes and seminal vesicles were weighed with a torsion balance. The testes were fixed with Susa or Zenker's fluid, stained with hæmatoxylin and eosin or Heidenhain's iron hæmatoxylin, then examined histologically. The content of gonadotrophic hormone of the serum obtained from the different groups of rats was determined by the mouse uterus method[5]. Groups of five immature female mice were injected subcutaneously with 0·5 ml. serum every 12 hr., then killed on the fourth day. The weights of mouse uterus were used as a criterion of gonadotrophic hormone-level in the blood of rats.

The groups of rats kept at the lower temperature of 18° C. had heavier testes and presented a normal picture of spermatogenesis, while the rats kept at the temperature of 35° C. showed partial atrophy of the seminiferous tubules and impaired spermatogenesis. Sertoli cells predominated in the picture and there

Table 1. INFLUENCE OF TEMPERATURE AND LIGHT ON TESTES AND SEMINAL VESICLE WEIGHTS OF RATS

Treatment	Body-weight	Testes-weight (mgm./100 gm. body-weight)	Seminal vesicle-weight (mgm./100 gm. body-weight)
Cold—light	219	1,001 ± 16·5	244 ± 35·70
Cold—dark	195	932 ± 62·00	112 ± 25·40
Cold—12 hr. light, 12 hr. dark	185	823 ± 66·10	127 ± 33·40
Temperature—light	194	785 ± 50·7	245 ± 44·2
Temperature—dark	227	841 ± 28·3	180 ± 20·2
Temperature—12 hr. light, 12 hr. dark	233	708 ± 70·0	258 ± 40·90

± Standard error

Table 2. INFLUENCE OF TEMPERATURE AND LIGHT ON SERUM GONADOTROPHIN OF MALE RATS

Treatment	Mouse uterus-weight (mgm./100 gm. body-weight)
Cold—light	165·57 ± 10·11
Cold—dark	154·56 ± 17·10
Cold—12 hr. light, 12 hr. dark	163·14 ± 20·00
Temperature—light	291·53 ± 24·40
Temperature—dark	200·39 ± 8·66
Temperature—12 hr. light, 12 hr. dark	236·94 ± 17·10
Control mice	110·00 ± 9·16

± Standard error.

were a few spermatogonia cells. The gonadotrophic hormone contents of all rats kept at the high temperature were significantly greater than those of their respective groups kept at the lower temperature. This is in agreement with the results obtained in dogs[6]. Such a rise in the level of gonadotrophic hormone is probably due to decreased utilization of the hormone by the refractory testes.

As appears from the accompanying Tables 1 and 2, the rats exposed to light had significantly heavier seminal vesicles than those of the rats confined to darkness. Exposure to light was also accompanied with an increase in the level of gonadotrophic hormone in the blood and increased amount of interstitial tissue in the testes. This gives evidence of increased production and utilization of luteinizing hormone by exposure to light.

The rats exposed to 12 hr. light and 12 hr. dark had heavier seminal vesicles when kept at 35° C. than those of rats kept at 18° C.

It is thus concluded that exposure to light is accompanied by increased production of gonadotrophic hormone with predominance of luteinizing hormone, whereas exposure to cold is accompanied by increased size of the testes and improved spermatogenesis which is apparently due to a rise in level of follicle-stimulating hormone.

F. A. SOLIMAN

Physiology Department,
Faculty of Veterinary Medicine,
Giza, Egypt.

A. S. ABD-EL-MALEK

Veterinary Research Institute,
Doki, Egypt.

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HISTOLOGY

A New Type of Chromaffin Cells, probably storing Dopamine

von Euler and Lishajko[1,2] have shown that dopamine occurs in the bovine lung in amounts up to 100 times higher than those of noradrenaline. They also demonstrated that the distribution of dopamine—in contrast to that of noradrenaline—was not related to the adrenergic nerves. On the basis of these findings, they concluded that dopamine in the lung cannot merely be an intermediate metabolite in the synthesis of noradrenaline in the adrenergic axons.

Using a new method for determination of catechol amines, Carlsson and co-workers[3,4] systematically charted the occurrence of these amines in various animals. They found large amounts of dopamine in several tissues in ruminants (cow, sheep, goat) but not in any other animals hitherto studied. In view of the relatively large amounts found, Dr. Carlsson asked us to try to demonstrate the cellular localization of this amine by means of histochemical methods. Since dopamine—like adrenaline and noradrenaline—is easily transformed into insoluble dark pigments by oxidation with potassium bichromate[5], an attempt was made to locate this amine by means of the chromaffin reaction.

The tissues were treated with a potassium bichromate–chromate solution (as described previously[6]) with or without formalin. Adjacent pieces of the tissues were fixed in formalin. The pieces were embedded in 'Carbowax' and sections were mounted unstained or after staining with nuclear fast red (Gurr; 0·03 per cent aqueous solution containing 1·7 per cent aluminium sulphate).

Chromaffin cells differing from the classical chromaffin cells of the sympathetic nervous system (presumably storing adrenaline or noradrenaline; cf. von Euler[7]) were observed in several tissues. They were fairly small (6–10μ), round or somewhat elongated and contained fairly large granules (Fig. 1). Though distinct, the chromaffin reaction was rather weak (yellow to yellow-brown). In contrast to all other chromaffin cells examined (adrenal medulla, chromaffin cells in sympathetic ganglia and carotid

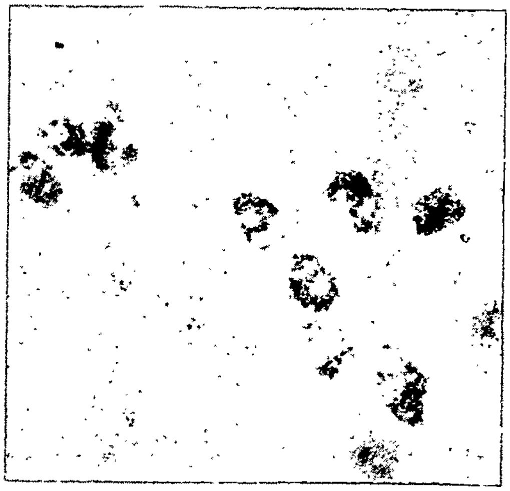

Fig. 1. Chromaffin cells in the visceral pleura from the cow. Fixation in bichromate–chromate–formalin. Staining with nuclear fast red. (× 1,200)

body, enterochromaffin cells, the cells of Adams-Ray and Nordenstam[8]), the cells observed had granules, which after treatment with bichromate–chromate–formalin, stained red within a minute with the nuclear fast red solution used and thus showed up well in the tissues.

That the cells are quite different from the enterochromaffin cells, now generally believed to contain 5-hydroxytryptamine, is evident from the following observations. They show the chromaffin reaction after treatment with bichromate without formalin, but the reaction is negative after fixation in formalin. Furthermore, the formalin-fixed cells do not give any diazo reaction (diazotized safranin[9]).

The cells have so far been observed in tissues from cow, sheep and goat; but not from pig, cat, rabbit, guinea pig or rat. Their distribution does not bear any relation to that of the autonomic nerves. In both these respects they are clearly different from the 'common' chromaffin cells of the sympathetic system and the recently discovered cells of Adams-Ray and Nordenstam.

The distribution of the cells follows closely the content of dopamine in the various tissues. Since this will be described in detail elsewhere, only two illustrative examples are mentioned. In the bovine lung the chromaffin cells are abundant in the connective tissue of the visceral pleura but rather scarce in the intrapulmonary tissue. Such cells are likewise relatively abundant in the cow liver capsule but practically absent in the parenchyma. Dopamine determinations (Carlsson and co-workers) showed that the amine content is substantially higher in the pleura than in the intrapulmonary tissue and that it is high in the liver capsule but very low in the parenchyma.

The presence of a new type of chromaffin cells showing a distribution in close accordance with that of dopamine suggests that the cells are storage structures for this amine.

BENGT FALCK
NILS-ÅKE HILLARP
ALF TORP

Department of Histology,
University of Lund. Nov. 12.

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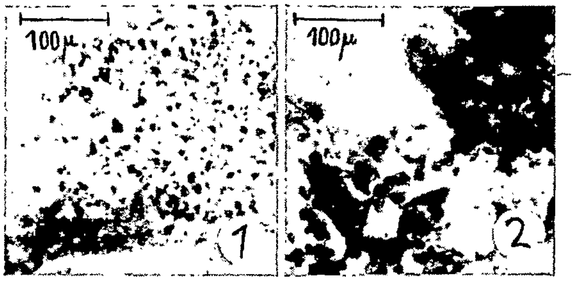
Histochemical Demonstration of Lipase and Alkaline Phosphatase Activity in the Fat Body of the Desert Locust

IN recent years several workers have studied by histochemical as well as quantitative methods the various metabolites and enzymes of the fat body of the locust. However, no information is available on lipase and alkaline phosphatase activity in this tissue. Here we report the results of a histochemical study undertaken to demonstrate lipase and alkaline phosphatase activity in the fat body of the desert locust (*Schistocerca gregaria*).



Fat body was removed from the abdominal region, after decapitation. The more readily dissected fat bodies thus taken consist mainly, if not solely, of true fat cells, the oenocytes being abundant towards the periphery, adjacent to the body wall[1]. Fresh frozen sections of this tissue was used throughout. For the demonstration of lipase, Gomori's 'Tween' method using 'Tween 80' as substrate was employed. 'Tween 80' is specifically acted upon by 'true lipase'[2]. Alkaline phosphatase was demonstrated employing the revised method of Gomori using sodium glycerophosphate as substrate. The procedures were the same as employed by us in our earlier work[3].

Figs. 1 and 2 present the photomicrographs of sections of the fat body of the locust treated respectively for lipase and alkaline phosphatase activity. Both the enzymes appear to be present in appreciable concentrations. In the case of the sections treated for alkaline phosphatase, there were present numerous round or ovoid bodies which stained intensely for the enzyme. These appeared to be the nuclei. The activity of these enzymes in the fat body is of special interest because this animal is known to utilize chiefly fat for muscular energy[4]. A high lipase activity in its flight muscles has also been recently demonstrated[5]. Similarly, high concentrations of lipase[6] and alkaline phosphatase[7] have been shown to be present in the fat-loaded fibres unlike the glycogen-loaded ones in the pigeon breast muscle, which is also known to utilize mainly fat for energy during sustained muscular activity[8]. Fat bodies of insects are often compared with mammalian liver since a number of metabolic reactions are known to be occurring in them. But more information is essential in order fully to justify such a comparison and the present study is an attempt in that direction.

Grateful thanks are due to Dr. K. B. Lal, plant protection advisor to the Government of India, for arranging the supply of the locusts used in this study.

J. C. GEORGE
J. EAPEN

Laboratories of Animal Physiology
and Histochemistry,
Department of Zoology,
M.S. University of Baroda,
India.
Dec. 6.

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BIOLOGY

A Rapid Method for examining Diapause Embryos of *Acheta commodus* W.

In the course of current work on the diapause of eggs of the common field cricket *A. commodus* it became necessary to determine the exact stage of embryonic development at which the arrest of development occurs.

Brookes[1] has described a method by which she traced the morphological development of non-diapause embryos of *Acheta*. The method involves fixing, staining and sometimes sectioning the eggs, and may take several weeks to complete.

In the present diapause studies, numerous observations are necessary to determine the onset and duration of diapause at different temperatures, so the long delay in the method used by Brookes would severely limit the scope of the work.

The desirability of using whole eggs rather than sections is evident. Slifer[2] found that by simply immersing eggs of *Melanoplus differentialis* in water the stages during katatrepsis can be observed under a dissecting microscope. However, diapause in *A. commodus* occurs during anatrepsis, the embryo is small and immersed in the yolk, and is not visible by this method.

The following treatment enables large numbers of eggs to be rapidly fixed and cleared in such a way that good optical differentiation of the embryo is provided without the use of stains (Fig. 1).

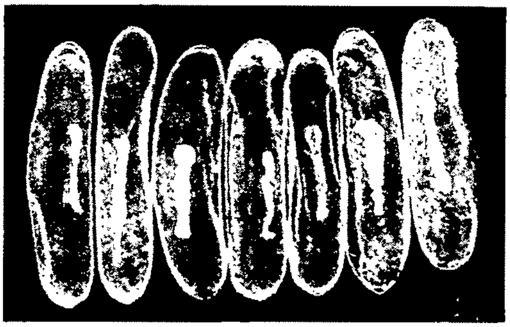

Fig. 1. Embryos of *A. commodus*, showing both diapause and early post-diapause stages of development. (× *c.* 12)

The eggs are placed in a watch box and soaked in water for about $\frac{1}{2}$ hr. The water is then drained off and replaced with the following mixture for 20–30 min. at 34° C.: glacial acetic, 2 parts; chloroform, 2 parts; absolute alcohol, 1 part. They are then transferred to a mixture of glycerol, 1 part, and alcohol (70 per cent), 1 part.

The first mixture will be recognized as having the same ingredients, in different proportions, as Carnoy's fixative. However, the fixative mixture is not effective. The time necessary in this solution varies with different batches of eggs according to their history, particularly the temperature at which they entered diapause. A preliminary trial for the timing is therefore desirable.

The time in the second solution is not critical. Clarity will be improved by standing at room temperature overnight and the improvement will continue for several days, but the stage of development can be identified within the first hour.

After the treatment the embryos are visible to the naked eye, but, for details of their morphology, the examination is made under a dissecting microscope. A black background and incident light are essential. Careful attention should be paid to the angle of incidence of the light.

I am indebted to Miss J. E. Kenyon for help in developing the method.

T. W. Hogan

Plant Research Laboratory,
Department of Agriculture,
Melbourne.

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Influence of Larval Population Density on Fluctuation in Mosquito Numbers

Recent ecological studies on culicine mosquitoes in and around a village in south-western Nigeria[1] revealed that the numbers of *Aedes aegypti* fluctuated throughout the year in a manner which could not be correlated with the observed external environmental factors. During a preliminary survey it was established that this species was restricted to breeding within the village area in clay water-pots of the type used for collecting and storing water, but that it was absent from natural habitats in the surrounding rain forest. The fact that it showed a typically domestic breeding pattern facilitated a study of the population dynamics throughout the year, and the method used for obtaining an index of breeding intensity was as follows. A number of clay pots were placed in the village and sampled weekly, the pre-adults (larvæ and pupæ) being removed for counting while the pots were cleaned and refilled with fresh water. The number of pre-adults found weekly was taken as an index of the changes in density of the breeding population within the village.

To study this numerical fluctuation of *A. aegypti* the value N was used as a population index for the village, it being equal to $n/(e)(w)$, where n is the total number of pre-adults taken per month, e is the number of experimental pots sampled per month and w is the number of weekly samplings per month. During the first four months of the year, N increased from 24·3 to 135·0, this being followed by a sharp decline in May (52·6), a slight increase in June (71·2) and a continued decline until October (21·3). There was then a further build-up, reaching a peak in December (71·2). It will be seen (Fig. 1) that these fluctuations were not related to the observed environmental factors, either directly or with a suitable time-lag to allow for the climate to be influencing the egg-laying behaviour of the female. It was thought that these fluctuations may have been dependent on density, related to the numbers of larvæ and pupæ found in the pots. Each pot may be considered as an isolated environment containing a unispecific population subject to intraspecific competition, such that any increase in numbers beyond a certain point would result in an increased pre-adult mortality due primarily to starvation.

An examination of this postulate was carried out in the laboratory in the following manner. A series of cultures was maintained, each containing different numbers of larvæ but in otherwise standard conditions of food supply and water volume. To ensure constant food supply, a solution of larval food was made up having the following constituents: wholemeal flour (46 per cent), ground oats (40 per cent), fish meal (8 per cent), dried skimmed milk (3 per cent), cod-liver oil (1 per cent), dried yeast

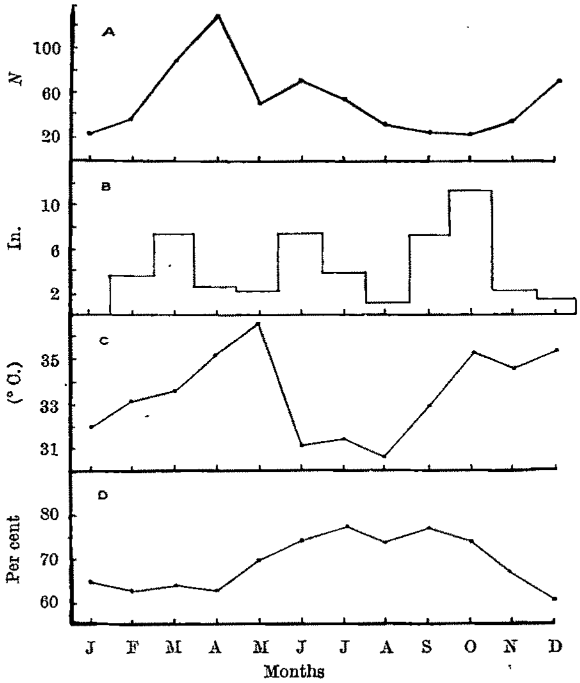

Fig. 1. *A*, the value of *N* for the village, 1956; *B*, the monthly rainfall; *C*, the monthly mean maximum temperature (° C.); *D*, the monthly mean minimum relative humidity (per cent). The monthly mean mimimum temperature varied in the range 18·1–20·5° and the monthly mean maximum relative humidity in the range 98·0–100 per cent

(1 per cent) and sodium chloride (1 per cent). 20 gm. of solid were added to 400 c.c. of water and heated to 100° C., the filtrate being used as the food solution. 40 c.c. of this were added to 1,000 c.c. of water and seven such cultures made up containing 10, 20, 30, 40, 50, 60, and 70 first instar larvæ respectively. A daily record was kept of development and mortality in each culture, the results for days 10 and 14 being given in Table 1.

In these laboratory experiments on the influence of population density on the survival and development of larvæ, each of the cultures described may be considered as a successive stage in the growth of a mosquito population.

In the field, the initial build-up may be accounted for by the early rains resulting in the hatching of the eggs which had remained viable over the dry season. At the time of the field study no rain fell between November 12, 1955, and February 9, 1956, but viability has been shown to persist in this strain for at least 24 weeks[2]. Thus the smallest culture may be taken to represent the commencement of the breeding season with the onset of the rains in February, each successive culture being a further stage in growth of population. It has been shown that in otherwise standard conditions, the greater the number of larvæ the longer the developmental period and higher the mortality. Thus it may be suggested at this stage that, in the field, as the population increas and relatively greater numbers of eggs were laid, t limits of the pre-adult environments were approache resulting in increased larval mortalities and a reduc egg-laying population. This decline was the followed by a recovery, it being suggested that there was adequate food material available for the smaller number of pre-adults. It may be concluded, therefore, on the present available evidence, that these fluctuations are essentially dependent upon density of population.

Table 1. Showing the Stages of Development on Days 10 and 14 of Cultures of *Aedes aegypti* Larvæ in Standard Conditions

Culture	No. of larvæ	Day 10	Day 14	Mortality (per cent)
1	10	8 IV, 2 III	10 *A*	0·0
2	20	20 III	20 *A*	0·0
3	30	30 III	15 IV	50·0
4	40	35 II	10 III	10·00
5	50	42 II	14 III	100·0
6	60	40 II	22 II	100·0
7	70	45 II	20 II	100·0

Note.—Roman numerals represent larval instars; *A* represents adults. After day 14 there was no further development in cultures 4–7.

Gordon Surtees

West African Council for Medical Research,
Lagos, Nigeria.
Nov. 20.

* Present address: 89 The Ridge, Orpington, Kent.

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Prolonged Survival of *Trichomonas vaginalis* at −79° C.

Successful cultures have recently been obtained from a stock strain of *T. vaginalis* which had been stored in a carbon dioxide cabinet for 26 months. The previous maximum survival reported was four months[1]. Since 1954, freezing in the presence of 5 per cent glycerol has been used for the maintenance of a strain of *T. vaginalis*. Stock cultures in the cabinet are replaced at approximately six-monthly intervals. Survival of cultures is shown on thawing by actively motile Protozoa and successful subcultures. The known maximum period of survival of such cultures has gradually been extended first to 8 months and then to 12 months.

Recently, four ampoules which had been frozon in September 1956 were examined. The first of these showed a few sluggishly motile Protozoa and was dispersed in 10 ml. of culture medium. There was no growth, probably because the sudden exposure to a glycerol-free medium disrupted the surviving cells. The suspensions from the next two ampoules which also showed very few active Protozoa, were each pipetted carefully to the bottom of separate tubes of medium so that the glycerol might diffuse out of the organisms as gradually as possible. Both these cultures grew, reaching maximum counts after 4 days incubation and thereafter subcultures grew normally.

The last ampoule was used in an attempt to obtain an accurate count of the proportion of surviving Protozoa. This failed, partly because the few survivors were too fragile to withstand the necessary manipulations and partly because many of the dead Protozoa were reduced to debris.

In all four samples active organisms were few and frail, and it may be that two years is close to the extreme period of survival for *T. vaginalis* under the conditions of storage, etc., used.

The growth and general appearance of the Protozoa after subculture were indistinguishable from a culture which had been stored for shorter periods, and both closely resembled the original culture prior to freezing. Antigens prepared from one of the recovered cultures and the one which had been more frequently passed were used for sensitizing sheep erythrocytes[2]. An anti-*Trichomonas vaginalis* rabbit serum, prepared in 1953, agglutinated red cells, sensitized with either of these antigens, to the same titre. The titre observed was somewhat less than that obtained with the same serum and culture five years previously, a difference which might be due to the age of the serum. No tests of pathogenicity were performed. As so few of the Protozoa survive, it may be that cultures derived from these form a selected group—this possibility cannot be ruled out.

The extreme period of survival recorded is not in itself important; but it does suggest that cultures may be kept for as long as a year with every confidence of survival.

M. G. McEntegart

Department of Bacteriology,
University of Aberdeen,
Foresterhill, Aberdeen.
Nov. 24.

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A Toad (*Xenopus lævis*) without Hæmoglobin

de Graaf[1] has recently described a specimen of *Xenopus lævis* Daudin completely lacking hæmoglobin. Another specimen showing a similar condition was found in a practical class in this Department on September 20. The individual was a male measuring 6·5 cm. from the tip of the snout to the vent. Unfortunately it had been partly dissected under tap water and then left for some hours before my attention was directed to the specimen. It was one of a batch of toads delivered from the Trout Hatcheries near Kingwilliamstown in the Eastern Cape Province and had been in the laboratory for only five days before dissection.

As with de Graaf's specimen, the blood vessels were colourless or white except for the chromatophores in their walls; the heart was pale cream; the lungs and liver grey and, particularly striking, the kidneys cream. In contrast to the specimen found by de Graaf, the spleen appeared to be enlarged and was a light brown and not a slightly yellowish-white. The most remarkable feature, however, was that the gall bladder was rich in green bile pigment. This seems to suggest that extensive destruction of hæmoglobin had been occurring very recently.

de Graaf has shown that normal *Xenopus* are able to withstand functional elimination of at least 80 per cent of their hæmoglobin by carbon monoxide treatment. Although survival without hæmoglobin is clearly possible, he is careful to point out that this does not prove that an animal without hæmoglobin can be as active as a normal one. Nevertheless, in his discussion de Graaf appears to be assuming that his animal without hæmoglobin had been in that condition all its life, with the implication that growth to maturity in natural conditions is possible in the absence of hæmoglobin. The evidence that hæmoglobin destruction had only just been completed in the present specimen suggests a different interpretation—namely, that the totally anæmic condition is a pathological state which may arise after the adult has become mature. If this is correct then the existence of such individuals does not permit any conclusions to be drawn as to the importance of hæmoglobin for survival in natural conditions.

D. W. Ewer

Department of Zoology,
Rhodes University, Grahamstown,
South Africa. Oct. 22.

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Inhibition of Influenza Virus Multiplication with a Glucose Antimetabolite (2-deoxy-D-glucose)

Optimal *in vitro* multiplication of influenza virus in the chorioallantoic membrane of the chick embryo is dependent upon the presence of glucose in the medium[1]. Evidence on the importance of endogenous glucose in *in vivo* synthesis of influenza virus is lacking. The relatively low toxicity in both experimental animals[2] and humans[3] of the potent glucose antimetabolite 2-deoxy-D-glucose suggested the feasibility of employing this compound in *in vivo* influenza virus infection. The present studies, undertaken in the intact chick embryo, demonstrate that the synthesis of influenza virus is markedly inhibited by 2-deoxy-D-glucose. Ancillary studies with *in vitro* systems show this inhibition to be reversible with glucose and therefore not related to permanent host cell damage.

The results of two representative experiments are shown in Fig. 1. In these experiments groups of six 10-day-old chick embryos were injected by the allantoic route with 12·5 or 25·0 mgm. of 2-deoxy-D-glucose or with water as a control. 18 hr. later, large inocula of influenza *B* (Lee) virus were introduced by the same route. These inocula were sufficiently large ($10^{7\cdot5}$ *EID*50, Exp. 559; $10^{8\cdot0}$ *EID*50, Exp. 560) to establish simultaneous infection of all susceptible cells to ensure a 'one-step' growth-curve. 8 and 24 hr. after the inoculation of virus, allantoic fluids from individual eggs were harvested and titrated with 0·5 per cent human '*O*' erythrocytes for the presence of viral hæmagglutinin. The geometric means of titres within groups were calculated and are plotted in Fig. 1. At 8 hr., viral concentrations in control eggs were close to maximal, while yields in eggs injected with 2-deoxy-D-glucose were

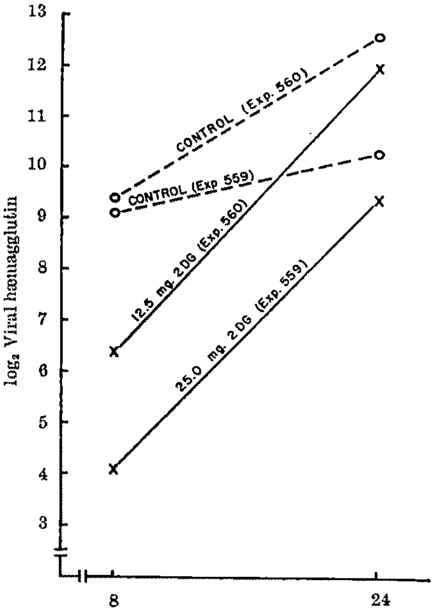

Fig. 1. Yields of influenza virus in allantoic fluids of chick embryos after prior injection of 2-deoxy-D-glucose (2DG). Geometric mean concentrations of virus derived from six individually titrated samples (allantoic fluids)/group. Chick embryos inoculated 18 hr. after injection of 2-deoxy-D-glucose with $10^{7\cdot5}$–10^8 50 per cent egg infectious doses (*EID*50) of influenza *B* (Lee) virus

3·0–5·0 $\log_2$ (8–32-fold) less. At 24 hr., however, hæmagglutinin concentration in eggs injected with 2-deoxy-D-glucose did not differ significantly ($>1·8$ $\log_2$) from control values. The apparent diminution in the inhibitory effect of 2-deoxy-D-glucose suggested: a declining efficacy of the metabolic block with time, or a slowed rate of viral synthesis with a delayed attainment of maximal titre as synthesis proceeded via less-efficient metabolic pathways not blocked with 2-deoxy-D-glucose. That the first interpretation is incorrect was demonstrated by an experiment in which virus was introduced 42 hr. after 25·0 mgm. of 2-deoxy-D-glucose at a time equivalent to the termination point of the experiments previously cited. The depression of yield of virus at 8 hr. was identical with that seen before. Hence it appears unlikely that interference with glucolysis had abated. This interpretation is supported by the failure of large amounts (50–250 mgm.) of glucose to prevent or reverse the effect of 2-deoxy-D-glucose in the intact chick embryo, although the effect induced *in vivo* was reversible *in vitro* by washing of chorio-allantoic membranes and the addition of supplementary glucose prior to virus infection. It is of interest that pyruvate, which may substitute for glucose in the *in vitro* synthesis of influenza virus[4], proved capable of inhibiting to a degree the restrictive effects on virus multiplication induced by 2-deoxy-D-glucose in the chick embryo. The utilization of pyruvate presumably is not blocked with 2-deoxy-D-glucose.

Other experiments have shown that synthesis of infective as well as hæmagglutinating virus is depressed with 2-deoxy-D-glucose, and that the ratio of hæmagglutinating to infective virus formed is equivalent to that of controls.

Preliminary experiments in mice have failed to demonstrate effects of 2-deoxy-D-glucose on either virus multiplication or the development of viral lesions. Further study of this relatively non-selective type of chemotherapy seems indicated, however, in view of the low toxicity of this antimetabolite. The possibility emerges that mere retardation of virus growth with preservation of host cell integrity may permit suppression of infection until natural host defences can be mobilized.

EDWIN D. KILBOURNE

Division of Virus Research,
Department of Public Health and Preventive Medicine,
Cornell University Medical College,
New York, 21.
Nov. 10.

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[1] Daniels, J. B., Eaton, M. D., and Perry, M. E., *J. Immunol.*, 69, 321 (1952).

[2] Ball, H. A., Wick, A. N., and Sanders, C., *Cancer Res.*, 17, 235 (1957).

[3] Landau, B. R., Lazlo, J., Stengle, J., and Burk, D., *J. Nat. Cancer Inst.*, 21, 485 (1958).

[4] Levine, A. S., Bond, P. H., and Rouse, H. C., *Proc. Soc. Exp. Biol. and Med.*, 93, 233 (1956).

Whale Remains in Glacier Ice

THE preservation of Pleistocene or Recent land mammals in the Siberian permafrost has long been known, but the literature does not appear to include mention of marine mammals preserved in ice. Particular interest, therefore, is attached to the discovery in 1958 of part of a whale carcass entombed in the ice-cored moraine of Sveabreen, Ekmanfjord, in Vestspitsbergen. The north-eastern lateral morain of Sveabreen projects into the fjord about two mile beyond the ice-front, and the find was made b members of the Birmingham and Exeter Universitie Spitsbergen Expedition near the seaward tip.

The ice-core of the moraine rises to about 20 f above the high-water mark and the dirt cover i probably about 3 ft. thick. Near the top of th ice-core, and within the adjacent moraine, the bone and (now decomposing) flesh and skin of a whale wer found. Melting of the ice and the removal of morain seem to be uncovering more of the carcass each yea and, from what could be seen, much of the bod behind the shoulder region appears to remai Several of the posterior vertebræ are exposed on th upper surface of the moraine so that their dors surfaces have suffered some damage. The head an shoulders have been carried away during present-da erosion of the moraine, which consists here largely water-worn pebbles and small boulders and mu containing "raised beach" fossils typical of th "*Mytilus* horizon", that is, of the Sub-Recent perio Weathered-out vertebræ and ribs were found on th shore. The length of the existing part of the anima is about 30 ft. so that its length when complete mus have been about 60 ft.

The question of how and when the animal becam entombed is a difficult one. One would expect a dea whale to float and hence decompose during th summer months, even if it died in the winter. It i suggested, therefore, that this specimen was trappe beneath ice, possibly the floating ice-front of Sveabreen, and held there. Advance of the ice pushe the whale, together with sediment and the enclose shelly fauna, from the fjord floor to the position wher the moraine so formed is now situated. The lon axis of the whale is more or less parallel to the lengt of the moraine. It may be fortuitous that it lies a the top. As long as it remained in the permafros the animal would not decompose. It is surprisin that the body remained intact during the movement.

A regional recession of the ice in the Arctic ha been taking place during the past 200 years an certainly Sveabreen has retreated some two mile during the past 45 years. The whale must hav reached its present position at least before thi recession began and probably during the previou major advance of the ice, which occurred as a resu of a severe deterioration of the climate in Sub-Recen times. Ahlmann[1] suggests that this advance ma have occurred about 2,500 years ago. Since the and with the further recession of the glaciers, isostatic recovery has raised the Sub-Recent littor deposits on the Ekmanfjord coast 2–3 m. above sea level and with them the overlying ice-cored moraine Thus it may be surmised that the carcass of the whal reached its present site most probably more tha 200 years ago but not more than 2,500 years ago This time-interval is a large one; but radiocarbo dating would perhaps narrow the likely limit within which the whale died.

D. L. DINELEY

Geology Department,
University of Exeter.

P. A. GARRETT

Geology Department,
University of Birmingham.

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[1] Ahlmann, H. W., *Norsk geogr. tiddsk.*, 13 (1954).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 26

Institute of Actuaries (in Staple Inn Hall, High Holborn, London, W.C.1), at 5 p.m.—Mr. Hilary L. Seal: "A Statistical Review of the Evidence for the Existence of Temporary Selection".

University of London Institute of Education (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Dr. C. A. Mace: "Field and Gestalt Theories".*

Institution of Electrical Engineers (at the Royal Festival Hall, London, S.E.1), at 6 p.m.—Dr. H. A. Thomas: "Automation" (Faraday Lecture).

Radar and Electronics Association (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 7 p.m.—Mr. D. W. Fry: "The Pinch Approach to Thermonuclear Reactions".

Tuesday, January 27

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. L. Brent: "A New King of Twin".*

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir Vivian Fuchs: "The Commonwealth Trans-Antarctic Expedition" (Thomas Holland Memorial Lecture).

University of London (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. G. W. Beadle (California Institute of Technology): "Transmission Mechanisms"*. (First of two lectures on "Mendelian Inheritance". Further lecture on February 3.)

Society of Instrument Technology (at Manson House, Portland Place, London, W.1), at 6 p.m.—Symposium on "Flow Measurement".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. P. Lloyd: "Some Aspects of the Engine Noise Problem".

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "New Light on Vision". Chairman: Prof. W. D. Wright. Speakers: Prof. R. W. Ditchburn, Prof. C. H. Graham and Dr. W. A. Rushton, F.R.S.

Wednesday, January 28

Geological Society of London (at Burlington House, Piccadilly. London, W.1), at 5 p.m.—Dr. R. J. Firman: "The Relationship between Joints, Faults and Mineral Veins in the Eskdale Granite (Cumberland) and the adjacent Borrowdale Volcanic Series"; Dr. W. I. Stanton: "The Lower Palæozoic Rocks of South West Murrisk, Ireland" (Paper read by Dr. G. Thomas).

Institution of Electrical Engineers, Supply Section (in conjunction with the British Nuclear Energy Conference, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. A. E. Harwood, Mr. P. Scott and Mr. B. H. Stonehouse: "Design of Electro-Mechanical Auxiliaries Directly Associated with Power-Producing Reactors".

University College (in the Eugenics Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Hald (University of Copenhagen): "A Survey of some Sampling Inspection Plans for Attributes".* (Further lecture on January 30.)

Challenger Society (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—201st Scientific Meeting. Dr. Marston C. Sargent: "Growth and Photosynthesis in the Giant Kelp of the Pacific Coast".

Institute of Information Scientists (at the Berners Hotel, 10 Berners Street, London, W.1), at 6 p.m.—Discussions on (1) Abstracting, (2) Information Retrieval with respect to the results of the International Conference on Scientific Information, held at Washington, November 1958.

Institution of Mechanical Engineers, Education Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Teaching of the Theory of Structures and Strength of Materials".

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Prof. D. B. Fry: "Theoretical Aspects of Mechanical Speech Recognition"; Mr. P. Denes: "The Design and Operation of the Mechanical Speech Recognizer at University College London".

Institute of Science Technology (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 6.30 p.m.—Prof. Dame Kathleen Lonsdale, F.R.S.: "Peaceful Uses of Atomic Energy in the Next 50 Years".*

Society for Analytical Chemistry, Microchemistry Group (in the Restaurant Room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Determination of Small Quantities of Toxic Substances in the Atmosphere", opened by Dr. J. G. Gage.

Pharmaceutical Society of Great Britain (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Mr. K. R. Fell: "A Pharmacognosist in Nepal".

British Psychological Society, Medical Section (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 8.15 p.m.—Annual Meeting. 8.45 p.m.—Mr. A. Plaut: "Aspects of Consciousness" (Chairman's Address).

Thursday, January 29

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. A. Myers and Prof. R. D. Preston: "Fine Structure in the Red Algae", "The Structure of the Cell Wall of *Rhodymenia palmata*", "A General Survey of Cell Wall Structure in the Red Algae"; Mr. E. G. Gray: "Electron Microscopy of Collagen-like Connective Tissue Fibrils of an Insect".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. C. T. Ingold, Mr. F. C. Webber and Dr. Irene M. Wilson: "Marine Fungi".

University College, Faculty of Laws (in the Eugenics Theatre. Gower Street, London, W.C.1), at 5 p.m.—Mr. D. W. M. Waters: "The Rating of Charitable and Similar Institutions".*

Institute of Biology, London Branch (at 41 Queen's Gate, London, S.W.7), at 7.30 p.m.—Dr. R. L. Knight, O.B.E.: "Fruit-breeding—a Survey of Recent Work"* (Annual Research Survey No. 4).

Thursday, January 29—Friday, January 30

Challenger Society (joint meeting with Representatives from the Marine Laboratories (Development Commissioners' Scheme), in the Lecture Theatre of the British Museum (Natural History), London, S.W.7), at 10 a.m. daily—Scientific Papers.

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2)—Convention on "Long-Distance Transmission by Wave-guide".

Friday, January 30

University College, Department of Pharmacology (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. W. V. Macfarlane (University of Queensland): "Chemical Agents and the Slow Potentials of Heart and Muscle Cells".*

University of London (in the Eugenics Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Hald (University of Copenhagen): "An Economical Sampling Inspection Plan based on *a priori* Distributions".*

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. R. S. Silver: "The Energy Balance in Steam Power Plant Feed Systems".

Women's Engineering Society, London Branch (at Hope House, 45 Great Peter Street, Westminster, London, S.W.1), at 7 p.m.—Mrs. I. H. Hardwich: "Some Uses of Electron Beams in Metallurgy".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. Yehudi Menuhin: "Art and Science as Related Concepts".

Saturday, January 31

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Frank Greenaway: "Chemistry in Antiquity".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer or Lecturer in the Department of Pure Mathematics—The Registrar, The University, Liverpool (January 31).

Director (man or woman, of high ability, with considerable experience in chemical research and interest in its application in industry, able to lead and inspire a large research staff and organize and manage the work of the laboratory) of the National Chemical Laboratory, D.S.I.R., Teddington, Middlesex—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S.4923/59 (February 2).

Lecturer (registered medical practitioner) in Medicine—The Registrar, The University, Manchester 13 (February 2).

Lecturer in Mathematics; a Lecturer in Chemistry; and a Lecturer in Education—The Secretary, Homerton College, Cambridge (February 6).

Cytologist (honours graduate in botany or agricultural botany), to undertake general cytological work, but will have an opportunity to engage in original research—The Secretary, Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian (February 7).

Lecturer (specially qualified in one or more scientific subjects) in the Institute of Education—The Registrar, The University, Liverpool (February 7).

Lecturer (Grade III or II) (with a good honours degree and some relevant research or teaching experience, preferably in the field of structures) in the Department of Civil Engineering—The Registrar, The University, Bristol 8 (February 16).

Senior Lecturer in the History and Philosophy of Science at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 16).

Lecturer (with special qualifications, and preferably some research experience in either glasshouse crops or fruit growing) in Horticulture—The Registrar (Room 22, O.R.B.), The University, Reading (February 18).

Director (with proven scientific ability in the field of nuclear sciences such as radiochemistry, nuclear physics, isotope techniques or theoretical physics and an interest and proven ability in using such fields of work to solve a wide range of scientific and applied problems) of the Institute of Nuclear Sciences, D.S.I.R., Wellington, New Zealand, to lead a research team of about forty scientists and carry out administrative duties therewith—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. *B*11/21/11 and mentioning *Nature* (February 20).

Lecturer or Assistant Lecturer (with a degree in physiology, biochemistry, pharmacology or experimental zoology and research experience in one of these branches) in the Department of Physiology and Biochemistry—The Secretary and Registrar, The University, Southampton (February 21).

READER IN BACTERIOLOGY at the Middlesex Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 23).

DEMONSTRATOR or SENIOR DEMONSTRATOR IN GEOGRAPHY, primarily to supervise class work in physical geography—The Registrar, University of Melbourne, Carlton, N.3, Victoria, Australia (February 27).

LECTURER IN AGRICULTURAL CHEMISTRY (BIOCHEMISTRY) at the Waite Agricultural Research Institute, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

LECTURER IN ORGANIC CHEMISTRY, and an ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (February 28).

LECTURER IN PHYSIOLOGY—Prof. A. A. Harper, Department of Physiology, Medical School, King's College, Newcastle-upon-Tyne 1 (February 28).

LECTURER (with a degree in science or veterinary science and undertaken postgraduate studies in parasitology) IN HELMINTHOLOGY OR VETERINARY PARASITOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or the Registrar, University of Queensland, Brisbane, Australia (February 28).

SENIOR LECTURER or LECTURER (preferably with a degree or diploma in veterinary medicine and a specialized knowledge of comparative physiology) IN THE DEPARTMENT OF VETERINARY PHYSIOLOGY; and a LECTURER (veterinary surgeon, or with a degree in physiology) IN PHARMACOLOGY—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (February 28).

SENIOR LECTURER, and either a LECTURER or ASSISTANT LECTURER IN ZOOLOGY at Makerere College (The University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 1).

RESEARCH ASSISTANT IN MATHEMATICAL STATISTICS in the Department of Applied Mathematics—The Registrar, The University, Liverpool (March 2).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS (2) IN CHEMISTRY, PHYSICS, ENGINEERING (including CHEMICAL ENGINEERING), METALLURGY, PHARMACOLOGY or related subjects—The Registrar, The University, Sheffield 10 (March 7).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY and PHYSICS—The Registrar, University College, Dublin (March 31).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY or PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

TURNER AND NEWALL RESEARCH FELLOW IN ENGINEERING, INORGANIC CHEMISTRY or PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

ASSISTANT EDITOR (full-time, with a university degree, preferably in the physical sciences, and interested in the general advancement of science—academic, industrial and social, no previous editorial experience necessary) of *Nature*—The Editor of *Nature*, Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2.

HEAD (preferably aged 30–40, with a good degree and previous experience) OF THE CHEMISTRY DEPARTMENT—The Headmaster, Winchester College, Winchester.

LECTURER or SENIOR LECTURER (graduate in physics, teaching experience and preferably research and/or industrial experience) IN PHYSICS—The Principal, Kingston Technical College, Fassett Road, Kingston-upon-Thames.

NATIONAL RESEARCH COUNCIL and other POST-DOCTORAL FELLOWS IN THE DEPARTMENT OF PHYSICS—Prof. H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

PHYSICAL CHEMIST (with an honours degree in chemistry and preferably a few years experience of applied research) IN THE BITUMINOUS SECTION of the National Institute for Road Research, South African Council for Scientific and Industrial Research, Pretoria, for work involving investigation of the different problems associated with the materials used for bituminous binders, and adhesion of tar, and bitumens to roadstone and the oxidation of tars and bitumens—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2.

SCIENTIST (first- or second-class honours graduate in physics or electrical engineering), to be directly responsible to the Superintendent of Orfordness outstation for the general direction and day-to-day management of a team engaged on a programme of advanced electronic instrumentation development and associated complex field trials—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. No. 2131/34.

SENIOR TECHNICIAN IN THE RADIOTHERAPY DEPARTMENT—The Medical Superintendent, Western Infirmary, Glasgow, W.1.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Forestry in England. Pp. 16. (London: Forestry Commission, 1958.) [1211

Report of the Commonwealth Trade and Economic Conference. Pp. 17. (Cmnd. 539.) (London: H.M. Stationery Office, 1958.) 1*s*. net. [1211

The British Council. Annual Report 1957–1958. Pp. vi+111+8 plates. (London: The British Council, 1958.) [1311

Is Management a Profession? By Lyndall F. Urwick. Second impression. Pp. 32. (London: Urwick, Orr and Partners, Ltd., 1958.) 3*s*. [1311

Tube Investments Limited. Chairman's Statement—Annual General Meeting, Grand Hotel, Birmingham, 8th December 1958. Pp. 12. (London: Tube Investments Limited, 1958.) [1311

The Presentation of Taxonomic Information: a Short Guide for Contributors to Flora Europaea. Compiled by V. H. Heywood. Pp. 24. (Leicester: The University Press, 1958.) 2*s*. 6*d*. net. [1311

Office of the Lord President of the Council. The Sheep Industry in Britain 1958: a Report by the Natural Resources (Technical) Committee. Pp. iv+52. (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [1311

The National Gallery, July 1956—June 1958. Pp. 121+12 plates. (London: The National Gallery, 1958.) 10*s*. [1311

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 57: Have Eggs of First Quality. Pp. 8+4 plates. (Belfast: Ministry of Agriculture, 1958.) [1711

Bulletins of Marine Ecology (formerly Hull Bulletins of Marine Ecology). Edited by Sir Alister Hardy, Dr. C. E. Lucas and R. S. Glover. No. 40, Vol. 5: Continuous Plankton Records: List of Records, 1955–1957. By Dora E. John and W. W. Brown. Pp. 44–50+plates 9–14. (Edinburgh: The Scottish Marine Biological Association, 1958.) 4*s*. 6*d*. [1711

Other Countries

United States Department of the Interior: Geological Survey. Professional Paper 293: Quaternary and Engineering Geology in the Central Part of the Alaska Range. A: Quaternary Geology of the Nenana River Valley and Adjacent Parts of the Alaska Range. By Clyde Wahrhaftig. B: Engineering Geology Along Part of the Alaska Railroad. By Clyde Wahrhaftig and Robert F. Black. Pp. viii+118+8 plates. n.p. Professional Paper 294-I: Structural and Igneous Geology of the La Sal Mountains, Utah. By Charles B. Hunt. Pp. iv+305–364+plates 39–45. n.p. (Washington, D.C.: Government Printing Office, 1958.) [1211

Western Australia: Geological Survey. Bulletin No. 111: The Exploratory Diamond Drilling of the Koolyanobbing Iron Deposits for Pyrite, Approx. Lat. 30° 50′ S., Approx. Long. 119° 45′ E. By H. A. Ellis. Pp. 141+2 plates. (Perth: Government Printer, 1958.) [1211

Food and Agriculture Organization of the United Nations. FAO Commodity Policy Studies No. 11: National Food Reserve Policies in Underdeveloped Countries. Pp. vi+70. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1958.) 5*s*.; 1 dollar. [1211

Symposium on Cancer of the Liver Among African Negroes held by the International Union Against Cancer, Kampala, Uganda, August 1956. (Union Internationalis Contra Cancrum, Acta, Vol. 13, Nos. 4–5.) Pp. 507–874. Symposium in Leopoldville, September, 1956. (Union Internationalis Contra Cancrum, Acta, Vol. 13, No. 6.) Pp. 875–975. (Louvain: Union Internationale Contre le Cancer, 1957.) [1311

United States Department of the Interior: Geological Survey. Water-Supply Paper 1424: Ground-Water Factors Affecting Drainage in the First Division, Buffalo Rapids Irrigation Project, Prairie and Dawson Counties, Montana. By E. A. Moulder and F. A. Kohout. Pp. vi+198+11 plates. n.p. Water-Supply Paper 1436: Surface Water Supply of the United States, 1956. Part 3-B: Cumberland and Tennessee River Basins. Prepared under the direction of J. V. B. Wells. Pp. viii+262. 1 dollar. Water-Supply Paper 1437: Surface Water Supply of the United States, 1956. Part 4; St. Lawrence River Basin. Prepared under the direction of J. V. B. Wells. Pp. x+407. 1.50 dollars. Water-Supply Paper 1438: Surface Water Supply of the United States, 1956. Part 5: Hudson Bay and Upper Mississippi River Basins. Prepared under the direction of J. V. B. Wells. Pp. xii+575. 1.75 dollars. Water-Supply Paper 1446: Surface Water Supply of the United States, 1956. Part 12: Pacific Slope Basins in Washington and Upper Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+346. n.p. Water-Supply Paper 1447: Surface Water Supply of the United States, 1956. Part 13: Snake River Basin. Prepared under the direction of J. V. B. Wells. Pp. viii+261. n.p. Water-Supply Paper 1463: Records of Springs in the Snake River Valley, Jerome and Gooding Counties, Idaho, 1899–1947. By R. L. Nace, I. S. McQueen and Arthur Van't Hul. Pp. v+62+2 plates. n.p. (Washington, D.C.: Government Printing Office, 1958.) [1711

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 4, No. 8: Angular Correlation in the Decay of Pions and Muons. By C. M. G. Lattes. Pp. 11+19 figures. Vol. 4, No. 9: A Cosmic Ray Jet in the 10^{15} Electron Volt Energy Range. By P. Fowler, P. S. Freier C. Lattes, E. P. Ney and P. H. Perkins. Pp. 3+3 figures. Vol. 4, No. 10: A Model of the Universal Fermi Interaction. By J. Leite Lopes. Pp. 6. Vol. 4, No. 11: Note on Leptonic Decay of Pion. By Prem Prakash. Vol. 4, No. 12: Nuclear Emulsion Processing and Loading with Metal Versene Complex. By H. G. de Carvalho and A. G. da Silva. Pp. 5+1 figure. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1958.) [1811

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Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

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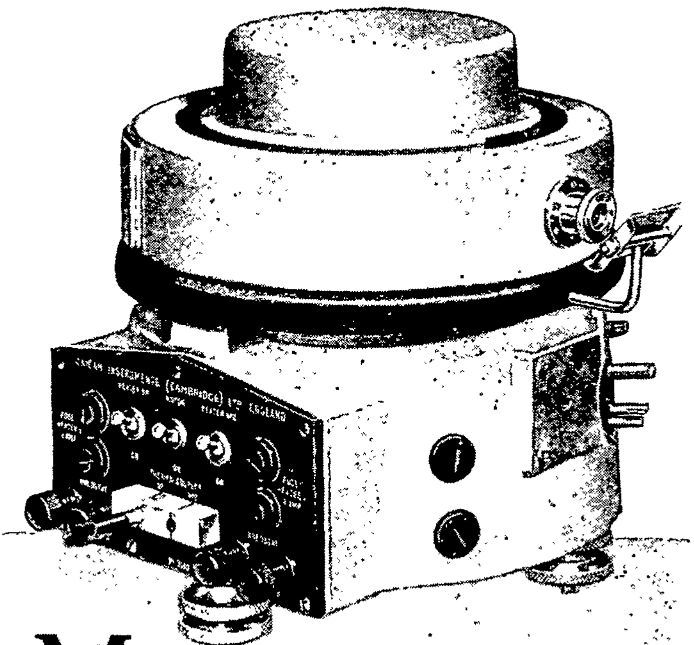

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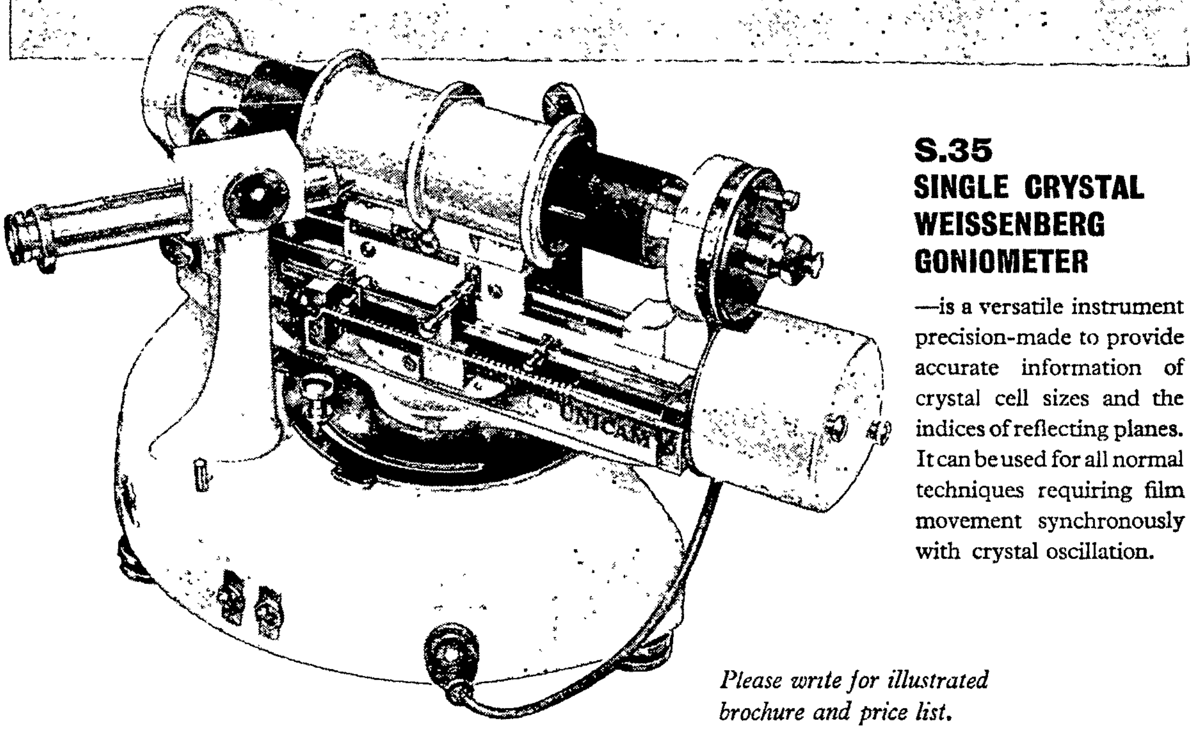

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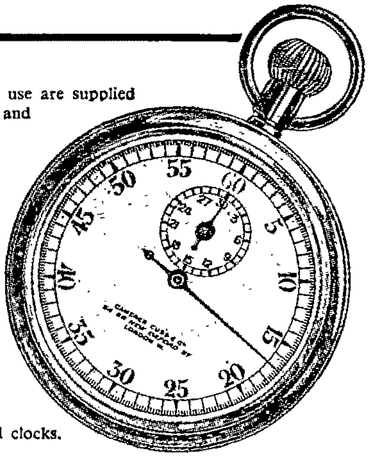

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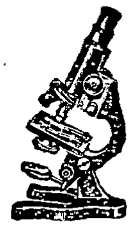

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POSITION AND FUNCTIONS OF THE RESEARCH ASSOCIATIONS

its first annual report last April, the Council for Scientific and Industrial Research said that it undertaking a comprehensive study of the way which the Department assists the promotion and lication of science in industry in Britain through work of grant-aided research associations. Apart n indicating that the Council was prepared to sider to what extent industries served by the arch associations could be expected to shoulder whole financial burden of an adequate research gramme either now or in the near future, the ort made no reference to immediate action. The ustrial Grants Committee of the Council, however, been surveying both the value of the work of the ciations and the methods used to assess and minister the Government grant ; and Government nt policy in relation to research associations is to reviewed during the present year in the light of survey.

Mr. John Wilson, lately director of research, tish Rayon Research Association, afterwards took nt-aided research associations as the subject of Hinchley Memorial Lecture to the British ociation of Chemists on October 29, but was ch more constructive than Dr. N. de Bruyne, in article in *The New Scientist* (3, 28 (78) ; 1958), to ose criticism he referred, as well as—though not te accurately—to that of Dr. H. Levinstein. Mr. lson's lecture was indeed concerned primarily to rify ideas as to the real functions of the grant-ed research association, and though he too recog-ed that the research association is at a disadvan-ge as compared with the research department of individual firm in selecting targets in techno-ical research, he fully recognized that there is a inite place for co-operative research. Quite apart m its function in providing for co-operation in the ack on common problems and perhaps particularly problems demanding very costly equipment or ources beyond those of individual firms, Mr. lson maintained that there is a definite place for research association in fundamental research, rticularly the systematic disciplined exploration of pecific field, which is irreconcilable with the com-te freedom of action of the universities.

The whole subject of co-operative industrial earch was carefully surveyed by Prof. R. S. wards in his book, "Co-operative Industrial search", published in 1950. Prof. Edwards did t indeed examine the essential functions of the earch associations, the broad fields of research ey should pursue or their relations with the iversities. His analysis was concerned with their nomic aspects and, as Dr. de Bruyne noted, advanced convincing arguments against the com-lsory levy ; though Dr. de Bruyne ignored the oad conclusion reached by Prof. Edwards both on his statistical evidence and on his inquiries into industrial opinion, that the research association is a sound industrial institution.

This is obviously the view of Mr. Wilson. He argues, indeed, that if research associations are used to attack problems common to groups of firms, the formation of a new research association will, in fact, lead to economy in the use of scientific man-power. Whether, however, it is cheaper to attack common problems on a co-operative basis or for individual firms to act independently and simultaneously depends on more than the selection of objectives which are worth while. It pre-supposes appropriate conditions of service, staff of similar high quality, and management capable of terminating an investigation at the right moment, as well as contacts between the research department and production which will ensure that the results are utilized as effectively when they come from the research association as they are within an individual firm.

There are questions of incentive and judgment involved here, and also of location, which can have a vital bearing on efficient communication, and these factors deserve more examination than they have yet received. Mr. Wilson and Dr. de Bruyne gave them no more attention than did Prof. Edwards ; but it is essential that they should be duly weighed in the re-assessment of the work of the research associations on which the Council of Scientific and Industrial Research is now engaged. Mr. Wilson makes an important point here in regard to staff, when he remarks, in urging that the research associations should give more attention to fundamental research, that the method of approach and type of man required for such work are quite different from those required in applied research. The difficulty can be over-stressed, for it is recognized in industry and has been overcome.

Much more important is the clear recognition of the relation between the research associations and the universities and also the research stations of the Department of Scientific and Industrial Research. This is probably essential in any event in order to check the danger of a research association becoming absorbed excessively in technical service, as distinct from research. A clear picture of the general structure of Britain's research effort and the respective functions of the universities, the independent research institutions, industry itself, the research associations and the Government research stations is necessary for the wise apportionment of effort and resources, and would contribute also to flexibility. It bears closely on the application of results, which is not simply a matter of the technique of communication but also, and sometimes mainly, of psychology.

Here, in touching on the communication of results, Mr. Wilson insists that the research associations must give some attention to information work; he suggests, nevertheless, that this function should be centralized in the Department's own Intelligence or Information Division. That is a debatable issue, too large to be discussed here; for it is, indeed, a facet of the library and information services of Britain as a whole, though it might be observed that Mr. Wilson's suggestion that such a step would release funds for research illustrates the way in which Government failure since the War to develop those services adequately has led to waste of effort and resources in research. Mr. Wilson is right, indeed, to point out how easy it is—and not only in the research associations—for resources to be diverted from the primary purpose and frittered away on secondary issues, even though these may be important. He mentions also education, and, valuable as has been the contribution of the research associations to technological education, this is not in itself a reason for their existence, and their research functions should be evaluated independently. Once the function of any particular research association has been clearly established and approved and the extent of the necessary resources determined, its ancillary contribution to technical education can be readily assessed. This should never be allowed to interfere with research itself, and it would be better to charge any direct loss involved to technical education as such, rather than allow it to appear in the research budget, unless it is impossible or impracticable to separate the two.

The main issue, however, is the proper function of the research association in Britain. Should it be, as Sir Lawrence Bragg suggested in 1942, an institution with a nucleus of permanent staff and with specialized and expensive equipment, but in the main with a constantly changing staff—a place to which men go for periods of intensive work, both from industry and the universities? Clearly, Mr. Wilson aimed at meeting the objection which Sir George Thomson advanced against Government research in his Fawley Foundation Lecture, in order to ensure the mobility which prevents fossilization. Mr. Wilson recognizes the value of the suggestion, but points out that success would depend on the existence of a virile organization in full operation, with a character, tradition and individuality of its own.

Mr. Wilson claims that the research associations possess the requisite resources for successful fundamental research, which requires the simultaneous impact of different disciplines, and can provide an atmosphere of freedom of discussion and publication which it is virtually impossible for the research department of an industrial firm to provide. He points out that, unlike the universities, they can accept directives from industry; but he suggests that their present low output of fundamental research could well be stimulated by administrative action in fixing the terms of future grants. He does not refer to the possibility that they might offer some contribution to the problem which the increasing cost of specialized equipment for research raises, and he does not mention the problem of continuity of finance.

These, however, are important factors on w among others, the decision as to the form in w research for any particular industry should prosecuted should depend. Conditions may widely from one industry to another, and alth there seems to be a sound *prima facie* case for tinuing in Britain the system of research associat in general, that is not to say that the existenc every research association is automatically justi Each needs to be examined in relation to its particular circumstances, and in relation to the o institutions which may serve that particular in try's need.

Finally, while the survey of the research ass tions and their work and functions on which Council of Industrial and Scientific Research is engaged is particularly welcome in view of the re announcement that the Department's resources to be substantially increased over the next five ye it is important that this re-assessment should made in relation to the functions of the Departme own research stations and of the universities th selves. Sound decisions cannot be made in isolati and while the expansion of the Departme resources makes it more desirable than ever that Department's organization and functions should periodically re-assessed as independently as poss in relation to present needs and conditions, i essential to realize that the Department is onl part of the nation's research effort. The repercuss on other sectors of the nation's effort need to considered also; nor should the large issue of administration and control of research be ignore

PAPERS AND CORRESPONDENC OF C. S. PEIRCE

Collected Papers of Charles Sanders Peirce

Edited by Arthur W. Burks. Vol. 7: Science Philosophy. Pp. xiv+415. Vol. 8: Reviews, Co spondence and Bibliography. Pp. xii+352. (C bridge, Mass.: Harvard University Press; Lond Oxford University Press, 1958.) Each 63*s*. net.

ON the east of the Atlantic, all too little is kn of the breadth and profundity of this Ameri philosopher's work. In the course of his life (18 1914), Peirce touched upon many problems wel advance of his time: to read his papers to-day i see what a considerable prophet he was. Ev have not hitherto been too kind to his memo six volumes of his writings appeared between 1 and 1935, after which, for a variety of reasons, noth more was done until 1954, when Harvard Univer initiated new progress, and these two volumes the result. They are most welcome.

The earlier work of Peirce consisted of studies deductive, inductive, and symbolic logic; now th are joined by contributions to science and philosop with some reviews and correspondence. The sali feature of this immense activity is the combinat of an enviable analytic power with sturdy pract experience. The latter came about because Pe spent some thirty years in the service of the Un tates Coast Survey, investigating astronomical and eodetic questions. In that sense he was a precursor of the distinguished school established in Britain by the late Sir Gerald Lenox-Conyngham at Cambridge. To read these papers, written in the early eighties, on the reasons for, and limitation of, pendulum experiments is to gain a substantial insight nto the physics of the Earth. Peirce must have possessed something of a flair for discerning the ssentials of his subject.

However, it is as a philosopher that Peirce will be emembered: his views on what to do and how to do it (or how not to do it) tend to be devastating when applied to research in general. He provides iscriminants for the worth-whileness of tackling any iven set of propositions experimentally. These criteria concern priorities, time, cost, and so on, and seem close to the considerations which any responsible director of research would apply to-day. In his time, naturally, the play was not for the high stakes f the mid-twentieth century, but the theory is all there, and of great interest. Another example of his apier-like mind is his approach to the old game of 'twenty questions'. On his showing, a score of interrogations is far too generous an allowance; something like half that number should reveal almost anything, if every shot carries the maximum possible epistemological weight. All this points inevitably towards the growth of a new science, that of cybernetics and information theory, utterly unknown during Peirce's life-time, but destined to become of major importance hereafter. If alive now, he would be a master of electronic computers. Another example of his power of foresight, as Prof. A. D. Ritchie has noticed, is his grasp of the influence of order of magnitude upon the aws applicable to single particles on one hand, and to assemblies on the other. Taken for granted o-day, Peirce perceived this more than sixty years ago.

The collection of reviews and correspondence strengthened by a detailed bibliography) portrays Peirce as a distinguished reviewer, kindly but ruthless in pressing an author's meaning to the limits of both philological and semantic significance. He seems to extract from a book considerably more than the writer probably intended to put into it. This applies more particularly to minor works, but when dealing with a major theme like Lobachevski's "Geometrische Untersuchungen", his comments are masterly.

It may be useful to indicate the plan and contents of the bibliography, more particularly since much of the material had its origin in rather unlikely places. The general scheme is: (1) Science of Discovery, (2) Science of Review, (3) Practical Science and Miscellaneous, (4) Book Reviews, (5) Life and Letters. This is, in fact, the author's own pattern of taxonomy, and depicts once again the unique quality of his mind. It should perhaps be added that a number of unpublished manuscripts still remain, which are of value for an assessment of his place in the development of philosophy in America. The general bibliography covers the period 1860–1911, with the addition of a few undated entries. Another section follows, containing items from *The Nation*, including Peirce's review of the two volumes of J. Willard Gibbs (1907). Lastly, comes a list of miscellaneous entries and indexes (cross-references, proper names and subjects).

If ever a work deserved the time-honoured title of the "Theory of Knowledge" these volumes certainly do. The editor and the Harvard University Press are to be congratulated upon their efforts.

F. I. G. RAWLINS

THE KILLING OF MICRO-ORGANISMS

Disinfection and Sterilization.

By G. Sykes. (Spon's General and Industrial Chemistry Series.) Pp. xviii+396+7 plates. (London: E. and F. N. Spon, Ltd., 1958.) 75*s.* net.

THIS book is a survey of the physical and chemical methods of killing micro-organisms. The scope is wide and the author, who has purposely avoided the subjects of chemotherapy and antibiotics, has condensed the material into 370 pages. Although this has prevented any detailed discussion it has permitted some cases of repetition in different sections of the book.

The subject-matter can be divided into two main sections, the physical and the chemical methods (sterilization and disinfection). Parts 1 and 5 of the book deal with the chemical methods and Part 2 with the physical ones. The disinfection and sterilization of air (Part 3), the disinfection of viruses (Part 4) and preservatives (Part 6) are treated separately.

Part 1 deals with the theory of disinfection and methods of testing. In the brief section on bacterial enzymes the difficulty of differentiating between disinfectant action and chemotherapeutic action has forced reference to some chemotherapeutic agents.

The treatment of the dynamics of disinfection is brief and no mention is made of the probit percentage survivor/time curves used by many modern workers, including Jordan and Jacobs, who are so often quoted in this section.

Details of many of the methods of testing are stated although little is given on the comparison between the methods, or with other methods of biological assay.

The chapters in Part 2 deal with sterilization by heat, radiations, filtration, gases and vapours, and the effects of cold, desiccation, and cellular disintegration. Each chapter is comple [illegible] in itself, but the reader will have difficulty in fin [illegible] which is the most efficient method for sterilizing [illegible] ecific material.

Part 3 is a concise an [illegible] l-balanced account of the disinfection and steriliza [illegible] of air.

Most of the short sectio [illegible] disinfection of viruses could be incorporated in [illegible] sections of the book since all the virus-inactiva [illegible] ents mentioned in this section have more deta [illegible] eatment in other sections.

In Part 5 the commonly used [illegible] ctants are discussed under the headings: phe [illegible] related compounds, dyes, quaternary amm [illegible] compounds, halogens, and heavy metals. The [illegible] are comprehensive but, although the coal [illegible] nfectants constitute the most widely used group [illegible] problems associated with their formulation receiv [illegible] little consideration. The testing of 'quats' wo [illegible] more appropriately discussed in Chapter 3.

It is essential that any book on disin [illegible] should discuss the problems of microbial spoil [illegible] Part 6 deals adequately with this, and quite [illegible] ly other causes of spoilage are not mentioned.

The book is well indexed and th [illegible] graphy is extensive, although the practice [illegible] ring to a 'private communication', which has [illegible] en made or is not going to be made freely av [illegible] ble, is very frustrating.

It will be a valuable reference volume in all microbiological libraries.

A. M. COOK

REFLEXIONS ON THE MOTILITY OF MUSCLE

The Motility of Muscle and Cells
By Prof. Hans H. Weber. Pp. vii+69. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1958.) 28*s*. net.

PROF. WEBER'S book might aptly have borne the sub-title '*multum in parvo*', for in 58 well-spaced pages of text he not only describes the biochemical basis of motility in striated and smooth muscle and in a number of unicellular organisms, but also puts forward a theory of the transformation of chemical energy into work during the contraction process. So far as the descriptive passages are concerned, there can be nothing but praise, particularly for the elegant techniques used in investigating the specialized movements of cells in mitosis, of fibroblasts and of *Vorticella*. Doubts quickly arise, however, when we consider the theoretical interpretation of the highly specialized contraction of striated muscle.

Prof. Weber sets out "towards the unknown region" from the postulate, well supported by innumerable experiments, that the energy for contraction is derived from the splitting of adenosine triphosphate by the actomyosin of the myofibrils in the presence, specifically, of magnesium ions, whereas no energy is required for relaxation, which is a passive process brought about by adenosine triphosphate, when its splitting is inhibited. To this he adds the further postulate that the physical changes of state take place according to the muscle model of Hanson and Huxley. This may be visualized, in the sense used by Prof. Weber, by considering the sarcomere at rest as a collapsible compartment, bounded by the *Z*-disks to each of which is attached a set of rigid pistons, the actin filaments, sliding freely within a centrally disposed cylinder, the *A*-band, made of parallel rigid filaments of myosin. During contraction, the pistons are envisaged as being pulled forcibly into the cylinder, rather in the manner of an iron bar into a solenoid. The problem is then to explain the nature of the attractive force in terms of these two premises. This Prof. Weber does by assuming the reaction occurs in steps, each of which consists of (*a*) a phosphorylation of a group on the actin piston, (*b*) the interaction of this group with a group on the myosin 'cylinder', resulting in dephosphorylation, and (*c*) further interactions between the dephosphorylated group and groups on the cylinder, each of which has a higher equilibrium constant than the one preceding it, or as Prof. Weber puts it, a lower standard energy in the temporary bonds formed. Attractive as this idea may be, it seems to be founded rather insecurely, because the results of Ulbrecht and Ulbrecht on which the very first interaction is based show that the postulated phosphorylation of protein by adenosine triphosphate occurs only with natural, and not with artificial, actomyosin, in spite of the fact that either sort of protein will form equally contractile threads. Apart from this objection, there is also the question of how sufficient of the energy derived from the primary phosphorylation is stored in the actin group to be available for the later interactions, without also postulating a complex series of configurational changes in this actin group, in other words, entropy changes, all of which must be reversed before the next step can take place.

When we pass from the steps to the integrat
movement of the whole sarcomere we encount
another difficulty which has apparently escaped th
notice of the adherents of the piston-and-cylind
model. That is, the question of how heat is giv
out during shortening. As is well known, Pro
A. V. Hill has been at great pains for many years
demonstrate once and for all that the total energy
contraction *in tres partes divisa est*, of which the fir
is the heat of activation, liberated explosively
soon as the stimulus arrives, and found to be consta
and independent of length or load; the second is th
heat of shortening, which is a linear function of th
degree of shortening and is also independent of loa
and the third is the work done. The latter two ma
up the so-called extra energy which can appear on
if the muscle is allowed to shorten and do wo
and which is entirely absent from the ideal isometr
twitch. Now, Prof. Weber's scheme does not ta
into account the first part of this energy release, th
heat of activation, presumably because it is difficu
to explain by simple thermochemical reasoning fro
this model or any other. It has been likened by so
workers to a charging-up process in contrast to shorte
ing, which is a discharge process; but if this were s
and no entropy changes were invoked, it woul
mean that more or less charged molecules would
left over at the end of a twitch, depending on wheth
the shortening were restricted or free. What woul
happen to the heat then ?

Secondly, reasoning from the model, Prof. Webe
concludes that it is unique in satisfactorily explaini
the origin of the heat of shortening; but this is onl
so if further restrictions are applied. For exampl
the scheme shows only one active group of acti
interacting at each step with four or more groups
myosin, although it is implicit that there are othe
behind it on the free part of the piston. If so, tw
courses are open: (1) interaction will occur wit
increasing frequency as the piston is pulled farthe
into the cylinder, that is, as more actin groups ar
opposed to more of the myosin steps, or (2) the acti
groups are discharged as they enter the cylinder an
afterwards remain inactive. If the first, then th
extra energy released in free shortening is a paraboli
function of the distance moved, that is:

$$-\text{Heat} = -K\,(n^2 + n)/2$$

where K is a constant and n is the number of step
This is clearly incompatible with Hill's equation an
must be rejected. On the other hand, if the secon
then only a restricted area at the end of the myosi
cylinders can contain active groups. Now this i
compatible with the linear heat relation, but it ru
counter to generally accepted views of the orientatio
of the *A*-band material and, for that matter, o
myosin itself. If we must reject this idea, then w
are left only with its opposite, that active groups ar
disposed throughout the length of the myosi
cylinder whereas those on the actin pistons ar
restricted to an area at their tips. This is a rath
more plausible concept, if no less revolutionary tha
the other, yet it still faces us with the problem o
how a long chain of homogeneous protein, perhap
extending for 10^4 angstroms, can be protected fro
interactions, except at its tip. Is it possible that thi
role is fulfilled by tropomyosin, a protein the functio
of which is as yet unknown ? Or must we abando
the piston and cylinder model in spite of its attractiveness in other ways ?

It is in raising these questions in such a precise and concise manner that the great merit of Prof. Weber's book lies, and while we may not agree with him over details, it is undeniable that he has successfully delimited the area where the answers will one day be found.

J. R. BENDALL

METEOROLOGICAL AND IONOSPHERIC STUDIES IN THE ARCTIC

Polar Atmosphere Symposium, Oslo, 2–8 July, 1956

Part 1: Meteorology Section. Edited by R. C. Sutcliffe. Pp. xi+341. 70*s*. net. Part 2: Ionospheric Section. Edited by K. Weekes. Pp. xiii+212. 60*s*. net. (London and New York: Pergamon Press, 1957 and 1958. AGARDograph No. 29. Published for and on behalf of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization.)

DURING and since the Second World War, networks of meteorological observing stations making upper-air observations by radio-sonde have been established in the American Arctic by the United States and Canada, in Greenland by Denmark and the United States and in the Russian sector by the U.S.S.R. In addition, temporary aerological stations have operated on ice floes and observations by regular Arctic weather reconnaissance flights have been made by using 'drop-sondes' along their tracks. It appears, however, that at the time of the conference much of the Arctic aerological data not only remained unpublished but also some were unavailable. The majority of the twenty-four papers on meteorology are concerned with the analysis of the available upper-air data though, besides these synoptic and aerological studies, there are also accounts of the recent climatic changes in the Arctic, of radiation measurements, of visual range and 'whiteout' and of the distribution of ice in Arctic seas. The discussions that followed the papers are admirably reported and make interesting reading, often ranging into wider issues than those raised by the papers that initiated them. They include, for example, an exchange of views between Scherhag, Sutcliffe, Namias and Fjörtoft on the warming effect on the stratosphere which Scherhag some years ago attributed to the occurrence of a solar flare. The revelation that many local winds ascribed to steep slopes are often, in fact, unconnected with the slopes, led to a suggestion that certain classical text-book concepts require revision. A further assertion that the concepts of synoptic analysis should be included in this revision called forth an immediate and vigorous defence of frontal analysis by distinguished meteorologists.

About half the twenty-one papers presented to the Ionospheric Section deal with the methods, results and theory of ionospheric drift measurements. The discussion naturally centred on the interpretation of the results in different conditions as representing true winds or the effect of electric fields, and on the difficulty of determining the height to which the drift measurements refer. There follow papers on prediction techniques applicable to problems of polar communication, on absorption measurements and one on a theory of meteor echoes of long duration based on atmospheric turbulence. This volume concludes with a short report of a discussion of measurements of absorption associated with the solar event of February 23, 1956.

The planning of work in the Arctic during the International Geophysical Year must have been materially assisted by this meeting of meteorologists and ionospheric physicists at Oslo during the summer of 1956, though it is hinted in at least one of the papers that the concentration of activity on the Antarctic would inevitably limit the scope of the effort in the Arctic.

JAMES PATON

INTRODUCTORY ELECTRONIC THEORY

An Introduction to Electronic Theories or Organic Chemistry.

By G. I. Brown. Pp. vii+209. (London and New York: Longmans, Green and Co., Ltd., 1958.) 15*s*. net.

A PROBLEM confronting all writers of elementary text-books on the mechanism of organic reactions is the marriage of theoretical conclusions with suitable experimental evidence which is within the knowledge of the reader. Elementary text-books often have the tendency to particularize general reactions of classes of compounds in terms of the simplest members. These are seldom characteristic members of the class. The problem is a difficult one and the author has courageously, and probably rightly, avoided it by omitting the experimental material so far as possible.

This book is clearly and easily written and the argument simply stated. The usual topics are discussed, including electrophilic and nucleophilic substitution, the molecularity of reaction, hydrolysis, addition and elimination reactions, hydrogen-bonding and homolytic and heterolytic fission. The book has also a good historical introduction and very useful chapters on the nature of bonding. There is also a timely appearance of the high value of the latent heat of sublimation of carbon, evidence for which is now compelling.

As each topic is dealt with separately, the book will prove a ready source of information as well as being useful for reference. The text is clearly printed and attractively presented, the whole work being well indexed. The diagram, except for the point mentioned below, is well constructed and produced.

There are some matters with which I disagree. The discussion of the nitration of *p-ter*butyltoluene comes to an erroneous conclusion; recent evidence strongly favours a steric explanation of the experimental observations. The suggested mechanism for the Hofmann degradation (p. 193), moreover, would not meet with universal approval.

Finally, there are some trivial errors. The display of the electrons in the diagram (p. 34) suggests an interpenetration of the valency orbits of the oxygen atoms, and the failure to assign the $—NO_2$ and —COOH groups to particular carbon atoms on p. 196 is confusing at first sight. Surprisingly, collinear has been mis-spelt.

In spite of these criticisms, however, I consider the book to be well constructed and deserving of serious study. If it reaches the classes of readers, sixth-form students, first-year university students and older chemists who are interested, as the author wishes, it will do much to ensure a greater appreciation of this important subject.

R. I. REED

Feedback Theory and Its Applications

By P. H. Hammond. (Applied Physics Guides.) Pp. 348. (London: English Universities Press, Ltd., 1958.) 35*s.* net.

A GOOD understanding of feedback theory is essential for electrical engineers and workers in allied fields. The basic principles of linear servomechanism theory have appeared in many books. Most practical servo-systems involve non-linear elements and it is pleasing to see that this field of study is well covered in this book in easily understandable form. A particular feature to be commended is the frequent description of practical electronic circuits, including values of components and details of operating conditions.

An introductory chapter gives the necessary mathematics for much of the work to follow, including Laplace transforms, differential equations and the convolution integral. The following chapters deal with basic linear feedback theory, including Routh's stability criterion and the Nyquist rule. In the latter the critical point is taken as $+1$ rather than the more conventional -1.

The frequency response function is discussed in detail and Bode's relation between gain and phase characteristics is clearly explained. Feedback principles are illustrated in a number of electronic circuits, including cathode followers and virtual earth amplifiers. Methods of stabilizing amplifiers with several stages by the control of the frequency response are explained. Many applications of virtual earth amplifiers are given and a circuit using positive and negative feedback is described. A chapter is devoted to stabilization techniques applied to servomechanisms, and such topics as the use of derivative of error and integral control to reduce steady-state error are described.

The treatment so far given is inapplicable to many practical servo mechanisms because these use non-linear elements. The phase-plane technique is now explained and examples of its application are presented. The analysis of non-linear feedback systems presents considerable difficulties and one method is to employ frequency-response techniques and make use of describing functions. Further chapters describe on-off controlled servo mechanisms and simulation of servo mechanisms using analogue computers.

This book will be of great value to all workers requiring a thorough grasp of feedback principles.

R. L. Grimsdale

The Fabric of Farming

By Prof. A. N. Duckham. Pp. 224 + 8 plates. (London: Chatto and Windus, Ltd., 1958.) 15*s.* net.

PROF. A. N. DUCKHAM has written this book for first-year students, rural science teachers, and any others who are interested in the relation of agriculture to man. Such a public, while not likely to be looking for a profound treatise, will none the less expect the subject to be treated in a scientific manner. Prof. Duckham does this by considering the growth of agriculture from two points of view—the historical and the bio-geographical. He describes the development of farming from the days when man fed himself by taking the food he found in Nature, and hunting for animals and fish, to the complex undertaking that we know it to be to-day. He then discusses the influence of climate and of locality on type of farming, and the factors which result in extensive farming in some parts of the world, and intensive farming in others. Intensity and complexity generally go together and in most modern systems the skill of farming is largely measured by the success with which natural and man-made resources are integrated to produce the highest income in relation to their cost. "Weaving the many components of modern farming into a living, persistent, and profitable fabric calls for managerial ability of a high order on the part of the individual farmer and for a vast array of industrial, technical and social supplies and services, that is, for a high level and a wide range of inputs of non-farm origin." This way of looking at farming is born of a different 'habit of thinking' from some schools of thought. It is certainly different from the conception of agriculture as a nucleus of husbandry with the so-called ancillary subjects or sciences to hand, ready to assist the main subject when called upon to do so. Prof. Duckham insists that integration is a 'mode of thought' rather than a 'set of principles'; this, indeed, gives the clue to his approach to his subject.

"The Fabric of Farming" will not compete with "Fream" or "Watson and More" as the students' *vade mecum* in his contests with examiners, but it will give him more ideas in 200 pages than many books two or three times as big.

Harwood Long

Blood Groups in Man

By Dr. R. R. Race and Dr. Ruth Sanger. Third edition. Pp. xix+377. (Oxford: Blackwell Scientific Publications, 1958.) 42*s.*

THIS is now the third edition of this book, which has been deservedly popular. Since the last edition many new blood-group antibodies have been discovered which define new blood-group antigens but, on the whole, these have been found to be associated with the known blood-group systems; indeed, the authors state that it looks as if we are nearing the end of the blood-group systems which can be detected by the tests in use up to now, and express the hope that for the future of the science of human genetics, and for the delight of blood groupers, many more systems exist and that their recognition only awaits the devising of suitable tests. This pin-points the importance of the technical advances in this field over the past few years, which have made so much progress possible, and also indicates the predominant interest of these workers in human genetics, which is more evident in this edition than it was in previous ones.

Much more is now known about certain blood groups, and their complexity has so increased that the chapters dealing with them have had to be lengthened; for example, no one would have thought, some years ago, that the P blood-group system would have attained the interest which it now has. All the new information has been included without increasing the size of the book, so that some subjects receive less space; for example, three chapters on Rh in a previous edition now become one. Where old material has been omitted a summary and references are retained—a help to those who are beginning their studies of this subject.

The authors state they have not altered the notation or adopted Prof. Ford's suggested blood-group notation, and this is a wise course to adopt in the present state of affairs; indeed, any such alterations ought to be by international agreement.

This book has now become an established favourite and the new edition will be welcomed by all those interested in human blood groups.

F. Stratton

METABOLISM OF NORMAL TISSUES AND NEOPLASMS *IN VITRO*

By Prof. J. H. QUASTEL, F.R.S., and I. J. BICKIS
McGill-Montreal General Hospital Research Institute, 3619 University Street, Montreal

As is well known from the pioneer work of Warburg, characteristic features of tumour metabolism are the high rates of aerobic and anaerobic glycolysis coupled with low respiratory-rates. It is equally well known, however, that a number of normal mammalian tissues show relatively high rates of anaerobic glycolysis, but in these tissues glycolysis is largely abolished under aerobic conditions when oxidative processes are proceeding normally. In most tumours, the high rate of anaerobic glycolysis is reduced possibly to half its value when oxygen is present, but the glycolysis still proceeds at a relatively high rate.

The phenomena of a moderate respiration-rate and high sustained aerobic and anaerobic glycolysis are displayed not only by tumours. Warburg reported that the mammalian retina possesses a high aerobic glycolysis, although he considered that some sort of damage occurs in the preparation or examination of the tissue. A variety of normal tissues possesses characteristics ascribed to tumours. For example, a high aerobic glycolysis obtains in placenta, in kidney medulla and in jejunum mucosa and in the myeloid cells of rabbit bone marrow. It seems, as Greenstein[1] has pointed out, that a *specific* tumour metabolism does not exist, and that no clear-cut distinction can be drawn between normal and tumour tissues on the basis of metabolic criteria. Yet tumours tend to show a fairly uniform metabolism, their chemical activities, however different in origin these tumours may be, resembling each other much more than do those of the many varieties of normal tissues that give rise to tumours. Tumours tend to converge, biochemically speaking, to a uniform type of tissue. Warburg[2] considers that cancer cells originate from normal body cells in two phases, the first phase being an irreversible injuring of respiration and the second being a process whereby some of the injured cells "succeed in replacing the irretrievably lost respiration energy by fermentation energy. Because of the morphological inferiority of fermentation energy the highly differentiated body cells are converted by this into undifferentiated cells that grow wildly—the cancer cells". He points out that the irreversible damage to respiration, which is held to be the first phase of carcinogenesis, "need not be an actual decrease in the respiration quotient but merely an uncoupling of respiration, with undiminished overall oxygen consumption". Warburg lays emphasis not so much on the absolute magnitude of respiratory-rate of tumour cells, but on the relation that obtains between respiratory- and glycolytic-rates. Weinhouse[3] points out that cancer cells show no obvious impairment of respiratory ability, there being "no doubt of the ability of miscellaneous tumours to convert glucose (and fatty acids) to carbon dioxide at rates similar in magnitude to that of non-neoplastic tissues". Moreover, the effects of metabolic inhibitors such as fluoride ion or dinitrophenol are similar in neoplastic and normal tissues[4]. There is no indication from such evidence that oxidative phosphorylation occurs in tumour mitochondria in a manner different from that in the non-cancer material.

It seems to us that more light may be thrown on the general problem of the relation between the aerobic and anaerobic aspects of metabolism, and on the significance of these aspects of metabolism for growth in tumours and normal tissues, by a systematic investigation of the quantitative relations existing between respiration, glycolysis and the rates of biosynthetic processes in these tissues.

If tumours, in spite of their abilities to carry out a variety of oxidations similar to those occurring in normal tissues, cannot utilize aerobic energy as efficiently as normal tissues owing to an uncoupling phenomenon, the ability of tumours to carry out certain biosynthetic changes aerobically should be diminished compared with that of normal tissues. Even the demonstration that tumour mitochondria resemble normal tissue mitochondria in bringing about oxidative phosphorylations does not necessarily imply that in the tumour cell the adenosine triphosphate made available by the mitochondria is as available for cell syntheses as in the normal cell. Only experiments with intact cells will make this information available.

We have, therefore, carried out experiments with tumours and normal tissues in an attempt to discover whether respiratory energy in tumours is less effective than that of normal tissues for biosyntheses, and whether glycolytic energy is superior to that of respiratory energy for such processes in tumour cells.

For the purpose of this investigation, we have concentrated our attention on the quantitative aspects of the incorporation of glycine into proteins of tumour and normal tissues. We have compared the amounts of glycine incorporated under aerobic and anaerobic conditions with the energy released by respiration or by glycolysis in terms of adenosine triphosphate formed by these processes. We have, in fact, compared the 'efficiencies' of a variety of tissues for amino-acid incorporation in terms of available adenosine triphosphate.

Our choice of a system of amino-acid incorporation for the study of energy utilization by tissues under aerobic and anaerobic conditions has been determined by the relatively recent studies that have shown that such incorporation is greatly dependent on the presence of adenosine triphosphate, or on the release of that substance. This incorporation may consist of an exchange reaction or a protein synthesis[7], but presumably a process of peptide-like bond formation occurs which is a system requiring energy[8-12]. It is known[13] that slices of normal rat livers and of hepatomas incorporate ^{14}C-labelled alanine or glycine into the slice proteins, the rate of incorporation into the hepatoma proteins being greater than that into the normal liver proteins. Zamecnik and Keller[14] point out that incorporation of several ^{14}C-labelled amino-acids into proteins takes place anaerobically in a cell-free liver homogenate so long as adenosine triphosphate or a system generating this substance is present. No competition occurs between the various amino-acids tested. Rabinovitz *et al.*[15] have found that incorporation of several labelled amino-acids into proteins of Ehrlich ascites carcinoma cells is supported anaerobically under conditions of active glycolysis (see also LePage, ref. 26, and Nyhan and Busch, ref. 27). They[15] show that 2,4-dinitrophenol inhibits oxidation-linked incorporation at concentrations at which it stimulates oxygen uptake, but it is a feeble inhibitor of amino-acid incorporation linked with glycolysis. A cell-free system incorporating ^{14}C-amino-acids into proteins has been prepared from Ehrlich ascites carcinoma cells[16], the activation of the amino-acid carboxyl group being also dependent upon adenosine triphosphate[17]. Ziegler and Melchior[18] point out that the amino-acid incorporation system of liver is dependent on integrity of the cell and is very susceptible to lack of oxygen, facts that can be interpreted on the basis of a demand for adenosine triphosphate both for activation and incorporation of amino-acid. A need for glucose for optimal incorporation of amino-acid into a tumour (Gardner lymphosarcoma) was demonstrated by Kit and Greenberg[19], who also found that glycolytic and respiratory inhibitors inhibit the incorporation. The incorporation of labelled glycine and alanine into lymphosarcoma cells was not greater than in the normal spleen cell[19]. Uptake, as well as incorporation, of amino-acids is a process requiring energy. Negelein[20] has demonstrated that uptake of L-histidine into a malignant rat sarcoma takes place anaerobically so long as glucose is present and that glucose stimulates the aerobic uptake.

Attempts have been made by us to answer the following questions:

(1) Is the respiration of tumours 'impaired' in the sense that energy derived from it is less effective in securing amino-acid incorporation into proteins than in normal tissues?

(2) Is the energy utilized for amino-acid incorporation into proteins as effective anaerobically (in the presence of glucose) as that aerobically, either in normal tissues or in tumours?

(3) Do tumours differ from other highly proliferating tissues, including those of the embryo, in the efficiency with which oxidative or glycolytic energy is used for incorporation of amino-acid into protein?

In the following preliminary studies we have investigated the incorporation of glycine-1-^{14}C into the proteins of Ehrlich ascites carcinoma cells and into the proteins of sarcoma 37, Novikoff hepatoma, Walker 256 carcinosarcoma, and a melanoma in *DBA* mice, as well as into the proteins of embryos (chick and rat) and of normal mammalian tissues.

We have calculated the amounts of incorporation in terms of adenosine triphosphate made available by respiration or by glycolysis. It is known[21] that tumour mitochondria give a P/O ratio of approximately 3·0, resembling, in this respect, the mitochondria of normal tissues[22].

We have used for the description of our results a term, which we call, provisionally, the 'efficiency quotient', which is the ratio of amino-acid incorporated into the protein to the adenosine triphosphate theoretically made available by respiration or by glycolysis.

If the respiration is given by the term Q_{O_2} then, taking P/O = 3·0, the available adenosine triphosphate is given by the term $Q_{ATP} = 6Q_{O_2}$. If the amount of incorporation of amino-acid into tissue protein is given by the term A in counts per minute per milligram dry weight protein, then the efficiency quotient E is equal to $A/6Q_{O_2}$. (The efficiency quotient could be equally well expressed in terms of moles of amino-acid incorporated per mole adenosine triphosphate. A simple calculation, given the experimental conditions, will give this ratio. We prefer the ratio as described, however, for the time being, until it is certain that the label in the protein is due only to the amino-acid incorporated.)

Again, if anaerobic glycolysis is given by the term $Q_{CO_2}^{N_2}$, then adenosine triphosphate made available by this process will be identical with this term, as a molecule of lactic acid liberated by glycolysis is accompanied by the formation of a molecule of adenosine triphosphate. Therefore, the efficiency quotient, for anaerobic glycolysis, will be given by the term $A'/Q_{CO_2}^{N_2}$, where A' is the amount of incorporation (counts per minute per mgm. dry weight protein) under anaerobic conditions in presence of glucose.

If respiration is carried out in presence of glucose, the efficiency quotient will be given by the term $A''/\{6Q_{O_2} + Q_{CO_2}^{O_2}\}$, where $Q_{CO_2}^{O_2}$ is the measure of the aerobic glycolysis and where A'' is the amount of amino-acid incorporation (counts per minute per mgm. dry weight protein).

Experimental Methods

All studies were carried out *in vitro* either with slices of tumours that had been grown in mice or rats or in fertile hen's eggs (at the chorio-allantoic membranes), or with washed ascites cells obtained from Swiss white mice after intraperitoneal injection. Ascitic fluid was withdrawn with a hypodermic syringe after six days growth and the cells were separated by centrifuging. They were washed three or four times with 8–10 volumes of cold isotonic saline to remove blood elements and soluble ascitic constituents. Sarcoma 37 was grown in white Swiss mice (subcutaneously or as ascites intraperitoneally) or in chick embryos. Normal tissues came mainly from hooded male rats in the weight-range 200–300 gm. 'Regenerating' liver was produced in these rats by surgical removal of the left and middle lobes. Rat embryos came from pregnant hooded rats and chick embryos came from white Leghorn eggs.

Solid tumours or normal mammalian tissues were cut into slices as soon as possible after killing the animals (by decapitation). The organs or solid tumours were placed in ice-cold Ringer media (without glucose) and tissue slices cut with a Stadie-Riggs slicer. Retina was cut into squares of 0·5 cm.^{2} and incubated as such. Embryos were used whole, with as little damage as possible, after removal of amnion and allantoic membranes. (Under the conditions of our experiments, no visible damage—apart from some change in opacity—took place in the embryos during the incubation procedure.) For each experiment tissue slices from one organ or tumour were used, with the exception of thymus, when slices from the organs of four animals were pooled. Tumours were only chosen that were free from visible necrosis.

The conventional Warburg manometric apparatus was used for estimating respiratory and glycolytic rates for the incubations in which the incorporation of glycine-1-^{14}C into the tissue proteins was measured. The Ringer media used were those described by Umbreit *et al.*[23], the calcium content, however, being 1·5 m*M*. Glucose, when added, was 10 m*M*. Glycine-1-^{14}C was diluted with non-radioactive glycine, so that the final concentration used was 2m*M*. The glycine was placed in the side tube of the Warburg manometer vessel and only tipped into the vessel after appropriate gassing with oxygen, or with

93 per cent oxygen + 7 per cent carbon dioxide or with 93 per cent nitrogen + 7 per cent carbon dioxide and thermal equilibrium at 37°. The total volume of medium in each vessel was 3 ml. In aerobic experiments (with air or oxygen) the centre wells of the manometer vessels contained potash for absorption of carbon dioxide. To ensure complete anaerobiosis, when using nitrogen – carbon dioxide mixtures, sticks of yellow phosphorus were inserted in the centre wells of the manometer vessels.

In all experiments, the results of which are quoted below, the radioactivity of the glycine-1-^{14}C incubated with the tissues was 10^5 counts per min. per vessel, the total incubation period being 1 hr. With ascites cells the incubation period was shortened to 30 min. to prevent too large a fall in *p*H in glucose media.

The wet weights of tissues used in each vessel were quickly obtained with a torsion balance, avoiding all possible injuries especially with retinæ or embryos. Dry weights were established by drying corresponding amounts of tissues, prepared and handled in exactly the same way, at 110° C., to constant weight. The amounts of tissues per vessel were kept approximately the same (80–100 mgm. wet weight).

After incubation, the manometer vessels were placed in crushed ice, their contents (cell and medium) were homogenized in a 'Teflon' pestle homogenizer, precipitated with trichloracetic acid (final concentration 13 per cent) and further homogenized. The precipitates were extracted three times with 6 per cent trichloracetic acid (first extraction carried out for 15 min. at 90° C. to remove nucleic acids), once with ethanol, once with ethanol-ether (3 : 1) at 60° C. for 10 min., once with ether, and finally the residual proteins were suspended in chloroform-ether (4 : 1), plated on aluminium disks and counted. The counting was done with a thin mica end-window Geiger-Müller tube and an automatic scalar and timer. The counted data were corrected for background and self-absorption. The activities given are the actual counts and are expressed as counts per minute per milligram dry weight protein.

Crabtree Effect and Aerobic Glycolysis

The relation between the values for aerobic glycolysis and the diminution of respiratory-rate brought about by the presence of glucose (Crabtree effect) is seen in the results, obtained with tumours, given in Table 1. These results indicate that the ratio of the aerobic glycolysis-rate $QCO_2(O_2)$ to the difference between the respiratory-rates found in the absence QO_2 and in the presence $QO_2(G)$ of glucose is constant, approximately 6, with the tumours under investigation.

Such a relationship would be expected if the adenosine triphosphate produced in the tumour cell is approximately constant, whether glucose is present or not, under the experimental conditions. We should then expect that adenosine triphosphate lost by operation of the Crabtree effect is approximately balanced by that gained by aerobic glycolysis. The following relation should hold :

$$\{QO_2 - QO_2(G)\} \times 2\frac{P}{O} = Q\,CO_2(O_2)$$

Table 1. RELATION BETWEEN AEROBIC GLYCOLYSIS AND CHANGE OF RESPIRATORY-RATE DUE TO GLUCOSE ADDITION

Tumour	QO_2 no glucose added	QO_2 with glucose present $= QO_2(G)$	$QO_2 - QO_2(G)$	$QCO_2(O_2)$	$\frac{QCO_2(O_2)}{QO_2 - QO_2(G)}$
Ehrlich ascites (1)	14·0	8·0	6·0	33	5·5
(2)	12·3	7·1	5·2	30	5·7
(3)	12·1	8·1	4·0	29	7·2
(4)	11·3	6·9	4·4	26	5·9
(5)	11·8	6·3	5·5	26	4·7 Average value = 5·8
Sarcoma 37 (solid, grown in fertile eggs)	9·8	6·6	3·2	20	6·2
Novikoff hepatoma	9·7	7·0	2·7	16·2	6·0
Walker 256 carcinosarcoma	6·8	5·4	1·4	9·0	6·4

The results given in Table 1 indicate that this relationship holds if P/O = 3·0, which is the experimentally observed value obtained with tumour mitochondria. The value of P/O = 3·0, for the intact tumour cell, would indicate that respiration and phosphorylation are tightly coupled in the tumour cells investigated.

The facts obtained are consistent with the view that there is a competition for adenine nucleotides by the hexokinase system in the tumour cell and the respiratory system in the tumour mitochondria[29,30]. Weinhouse[31] has pointed out that tumour mitochondria may be highly permeable to the adenine dinucleotide, diphosphopyridine nucleotide.

Effect of Glucose on the Aerobic Efficiency of Ehrlich Ascites Carcinoma Cells

Typical results showing the aerobic efficiencies of Ehrlich ascites cells for incorporation of amino-acid in the absence and in the presence of glucose are given in Table 2. The results make clear the conclusion that the efficiency with which these tumour cells, under aerobic conditions, incorporate glycine into their proteins as a result of availability of adenosine triphosphate is the same in the absence of glucose as it is in the presence of glucose. It is evident that energy released by tumour respiration, even in the absence of added glucose, is available for amino-acid incorporation, and is quantitatively as effective as the respiratory energy of rat embryonic cells as shown by observations given in Table 3. Moreover, the presence of glucose makes little difference to the efficiency of amino-acid incorporation in spite of the fact that the rate of respiration is considerably

Table 2. EFFECTS OF GLUCOSE ON AEROBIC AND ANAEROBIC EFFICIENCIES OF EHRLICH ASCITES CARCINOMA CELLS FOR INCORPORATION OF GLYCINE-1-^{14}C INTO PROTEINS

	No glucose added	Glucose added 10 m*M*
Aerobic		
QO_2	12·3	7·1
$Q_{ATP}(O_2) = 6 \times QO_2$	73·8	42·6
$QCO_2(O_2)$	—	28·4
$Q_{ATP}(O_2)$ (corrected for aerobic glycolysis) $= 6QO_2 + QCO_2(O_2)$	—	71·0
AO_2 = amino-acid incorporated aerobically into tumour protein (c./min./mgm.)	118	114
Efficiency quotient $= AO_2/Q_{ATP}(O_2)$	1·6	1·6
Anaerobic		
$QCO_2(N_2)$	2·1	57·3
$Q_{ATP}(N_2) = QCO_2(N_2)$	2·1	57·3
AN_2 = amino-acid incorporated aerobically into tumour protein . (c./min./mgm.)	1	115
Efficiency quotient $= AN_2/Q_{ATP}(N_2)$	—	2·0

Table 3. EFFICIENCIES OF AEROBIC AND ANAEROBIC INCORPORATION OF GLYCINE-1-^{14}C INTO TISSUE PROTEINS

	Q_{O_2}(G)	A_{O_2}(G) (c./min./mgm.)	E_{O_2}(G) (corrected for aerobic glycolysis)	$Q_{CO_2}^{N_2}$	A_{N_2}(G) (c./min./mgm.)	E_{N_2}(G)
Ehrlich ascites carcinoma	7·1	137	1·9	62	138	2·2
Sarcoma 37 (subcut. from mice)	5·0	60	1·5	19·7	24	1·2
Sarcoma 37 (from fertile eggs)	6·6	105	1·8	40·1	89	2·2
Sarcoma 37 ascites (from mice)	4·5	97	2·0	44	102	2·3
Novikoff hepatoma	7·0	80	1·5	33·6	68	2·0
Walker 256 carcinosarcoma	5·4	70	1·6	27·2	55	2·0
Melanoma *S*.91 (*DBA* mice)	4·6	45	1·3	16·7	25	1·5
Embryo, rat	10·9	121	1·7	21·8	29	1·3
Embryo, chick (6th day)	14·8	221	2·5	30·6	45	1·6
Rat liver	6·5	33	0·8	2·2	0·0	0·0
Rat 'regenerating' liver (42nd hr. after operation)	10·0	85	1·4	3·2	0·0	0·0
Rat kidney cortex	22·2	9	0·07	2·8	0·0	0·0
Rat kidney medulla	19·9	20	0·17	11·5	1	0·09
Rat spleen	6·3	48	1·2	4·6	2	0·4
Rat thymus	8·8	81	1·5	12·7	9	0·7
Rat lung	4·7	31	1·1	5·7	2	0·3
Pigeon pancreas	4·8	42	1·4	4·6	1·0	0·2
Rat brain	12·8	2	0·03	9·4	0·0	0·0
Cattle retina	10·2	4	0·07	32·4	3	0·1

reduced by the presence of glucose. (Calculation shows that only a very small fraction of the available adenosine triphosphate is used for incorporation of glycine, approximately one mole of glycine being incorporated for 500 moles adenosine triphosphate released.) The diminution of available adenosine triphosphate by the reduction of respiratory-rate is apparently almost exactly balanced by that released by aerobic glycolysis. This phenomenon applies to other experimental tumours that we have examined and would seem to indicate that the high rate of aerobic glycolysis characteristic of tumours is a means whereby the tumour cell may retain its content of available adenosine triphosphate undiminished in spite of the operation of the Crabtree effect.

It has been shown by Emmelot and van Vals[24] that the incorporation of DL-glutamate-1-^{14}C and DL-leucine-1-^{14}C into the proteins of mammary carcinoma ascites cells is essentially the same whether glucose is present or not, a fact in agreement with the results given in Table 2. On the other hand, Davis and Busch[25] point out that the specific activities of proteins of slices of Walker 256 carcinosarcoma, following aerobic incubation with L-aspartate, L-glutamate, or L-alanine, all uniformly labelled with carbon-14, are markedly enhanced by the presence of glucose. It is possible that this result is partly (if not wholly) due to the aerobic conversion of each of these amino-acids, which are uniformly labelled, in presence of glucose, to a mixture of radioactive amino-acids the incorporations of which are independent of each other[14]. Nyhan and Busch[26] have indicated that L-glutamate is metabolized by Walker 256 carcinosarcoma *in vivo*.

Effect of Glucose on the Anaerobic Efficiency of Ehrlich Ascites Carcinoma Cells

Glucose is essential for anaerobic incorporation of amino-acids into Ehrlich ascites carcinoma cells. Results given in Table 2 show that the efficiency of glycolytic energy for incorporation of glycine into the tumour proteins is a little higher than that of respiratory energy. Both quotients, however, for the tumours investigated are of the same order of magnitude, and a variety of experiments have shown that the aerobic and anaerobic efficiency quotients for incorporation of amino-acid into proteins of the tumours investigated are approximately equal.

The aerobic efficiency is calculated on the basis of P/O = 3·0 for tumour respiration. If the value of P/O is significantly less than this, the 'efficiency' of respiratory energy for incorporation of amino-acid would increase and exceed that of glycolytic energy. It is evident that the results do not support the hypothesis that there is any 'impairment' of tumour respiration in the sense that respiratory energy is uncoupled from phosphorylation and, therefore, from an accompanying biosynthetic process such as incorporation of amino-acid.

It would be expected that the efficiency of adenosine triphosphate for incorporation of amino-acid into the tumour proteins would be independent of its source of production, either respiration or glycolysis. The fact that experiments with intact tumour cells show that aerobic and anaerobic efficiency quotients are approximately equal is good support for the conclusion that adenosine triphosphate is the main energy factor in the process of incorporation of amino-acid into the proteins of intact cells.

Efficiencies of Aerobic and Anaerobic Incorporation of Glycine into Tissue Proteins by Tumours and by Normal Mammalian Cells and Embryos

Results of a survey of the relative rates of incorporation of glycine-1-^{14}C into the proteins of tissues under aerobic and anaerobic conditions, glucose being present under both conditions, are given in Table 3. They demonstrate the following facts:

(1) The highest efficiency ratios, both aerobic and anaerobic, occur with the most rapidly proliferating tissues, namely, tumours and embryos. Thymus and pancreas, among normal mammalian tissues, have the highest aerobic efficiencies—possibly this is connected with their high capabilities for synthesizing proteins.

(2) The ratio of anaerobic efficiency to aerobic efficiency approximates to unity with tumours, the anaerobic value being usually a little higher than the aerobic. With adult tissues, the aerobic efficiency term usually exceeds the anaerobic value; this occurs also with embryos.

(3) Adult normal tissues having high respiratory activities (for example, kidney cortex, brain cortex) may have low aerobic efficiencies for the incorporation of glycine into their proteins. Similarly, normal tissues having relatively high anaerobic glycolytic activities (for example, kidney medulla, retina) may have little or no anaerobic efficiencies for the incorporation of glycine into their proteins.

Table 4. RELATIVE EFFICIENCIES OF EHRLICH ASCITES CARCINOMA AND CHICK EMBRYO FOR INCORPORATION OF GLYCINE AND L-PHENYLALANINE INTO PROTEINS

		E_{O_2}(G)	E_{N_2}(G)
Glycine-1-^{14}C	Ehrlich ascites carcinoma	1·6	1·7
	Chick embryo	2·4	1·5
Phenylalanine-2-^{14}C	Ehrlich ascites carcinoma	1·3	1·2
	Chick embryo	1·5	0·9

It should be pointed out that the aerobic efficiency quotients for incorporation of amino-acid into the proteins of adult tissues and embryos will need a small correction for the amount of radioactive protein produced from the radioactive carbon dioxide formed by oxidation of the amino-acid. This is largest with kidney cortex, but is negligible with Ehrlich ascites carcinoma cells and sarcoma 37, or thymus, which bring about very little oxidation of glycine to carbon dioxide. Chick embryo, rat brain cortex and rat liver have about one-sixth of the oxidizing power of rat kidney cortex on glycine for equivalent weights of tissue.

The results given in Table 3 make clear the fact that in the development of embryo into adult organs a marked drop takes place in the ability of the tissue to incorporate glycine into its proteins, although aerobically, and anaerobically with certain tissues (kidney medulla, brain cortex, retina), energy is apparently available in amounts comparable with those in the embryo. Further investigations are needed to establish the reasons for the diminished efficiency of adult tissue for incorporation of amino-acid into their proteins ; but one possible cause may be the development in the adult tissues of new enzyme systems dependent upon adenosine triphosphate, which are needed for the special functions of these tissues. Less adenosine triphosphate, therefore, is available for their amino-acid incorporating systems. The relative lack of the ability to incorporate amino-acid observed in adult tissues such as kidney or brain cortex, under anaerobic conditions in presence of glucose, points to the fact that in such tissues cytoplasmic, or extra-mitochondrial, adenosine triphosphate (made available by anaerobic glycolysis) cannot be used for incorporation of amino-acid. This stands in contrast to the effects of embryonic (or tumour) glycolysis. Further investigations, based on these conclusions, may help to throw light on the nature of the specific biochemical changes that arise with differentiation and growth of the embryo into the adult stage.

Observations recorded in Table 4 show that the conclusions concerning the incorporation of glycine into the proteins of Ehrlich ascites carcinoma cells and chick embryo apply also to L-phenylalanine, which was used under exactly the same experimental conditions as glycine. Investigations with other amino-acids are proceeding.

Tumour and Embryo

Tumours and embryos, which resemble each other in having relatively high efficiencies for the aerobic and anaerobic incorporation of amino-acid, show, so far as their metabolism is concerned, a number of significant differences. For example :

(1) The presence of glucose, which depresses respiratory activity of tumours, has but little effect on that of rat or chick embryo.

(2) The presence of malonate greatly depresses both the rate of respiration and the rate of incorporation of amino-acid into proteins of Ehrlich ascites carcinoma cells and of chick embryo in the absence of glucose. These results, which are shown in Table 5, are consistent with the fact that the citric-acid cycle operates in these tissues[31]. When glucose is added, however, malonate exercises relatively little effect on the rate of respiration of the tumour, or on the rate of incorporation of glycine, in contrast to its large effect on embryo metabolism in the presence of the sugar. It appears, therefore, that in the presence of the respiratory poison, which blocks incorporation of amino-acid into tumour protein, glucose reverses the effect—a phenomenon not seen with embryo. In this respect embryo resembles adult tissue more than it resembles tumour. Nyhan and Busch[27] have shown that malonate suppresses the specific activity of proteins of Walker 256 carcinosarcoma exposed aerobically to labelled glutamate, and that the addition of glucose alleviates this suppression.

The reversing effect of glucose on the depressing effect of metabolic inhibitors on the amino-acid incorporation of tumours is also seen in its action on Ehrlich ascites carcinoma cells in presence of bilirubin or 2 : 4 dinitrophenol. Representative results obtained with ascites cells, given in Table 6, indicate that bilirubin can act as an uncoupler of phosphorylation from oxidations, a conclusion already reached by Zetterström and Ernster[32] in their studies of the effects of bilirubin on liver mitochondria. The substance, at low concentrations, suppresses incorporation of glycine into the tumour proteins, an effect partially reversed by the addition of glucose. It abolishes the Crabtree effect, and resembles in these respects the action of 2 : 4-dinitrophenol (Table 6). It might be noted in this connexion that sarcomycin, an inhibitor of growth of Ehrlich ascites carcinoma, inhibits glycine incorporation into ascites proteins[33]. The inhibition is diminished by the presence of glucose, but not as much as when bilirubin or dinitrophenol is the inhibiting agent.

Table 5. EFFECTS OF SODIUM MALONATE ON METABOLISM OF EHRLICH ASCITES CARCINOMA AND OF CHICK EMBRYO (5 DAYS OLD)

	Q_{O_2}		Glycine-1-^{14}C incorporation into proteins (c./min./mgm.)	
	Ascites	Embryo	Ascites	Embryo
No glucose present				
Without malonate	10·9	8·0	144	159
With malonate 20 m*M*	4·8	5·6	12	69
With glucose present				
Without malonate	5·3	7·8	138	172
With malonate 20 m*M*	4·3	4·8	119	60

Table 6. EFFECTS OF BILIRUBIN AND DINITROPHENOL ON METABOLISM OF EHRLICH ASCITES CARCINOMA

	Q_{O_2}	Glycine-1-^{14}C incorporated in proteins (c./min./mgm.)
No glucose present		
Control	13·0	83
With bilirubin		
0·16 m*M*	8·8	13
0·32 m*M*	1·3	4
With 2 : 4-dinitrophenol		
0·1 m*M*	15·5	36
Glucose (10 m*M*) present		
Control	6·5	110
With bilirubin		
0·16 m*M*	10·3	51
0·32 m*M*	10·8	52
With 2 : 4-dinitrophenol	15·3	87

The fact that the addition of glucose may restore to the tumour, in the presence of inhibitors of oxidative phosphorylation, its ability to incorporate amino-acids in its proteins, emphasizes the biological importance of this sugar in enabling the tumour cell to withstand the toxic effects of certain metabolic poisons.

Summary

(1) The ratio of rate of aerobic glycolysis ($Q_{\rm CO_2}({\rm O_2})$) to the difference between the respiratory-rates found in the absence ($Q_{\rm O_2}$) and in the presence ($Q_{\rm O_2}({\rm G})$) of glucose is constant, approximately 6, with the experimental tumours investigated (Ehrlich ascites carcinoma cells, sarcoma 37, Novikoff hepatoma and a melanoma). This relationship is expected if the adenosine triphosphate produced in the tumour cell is approximately constant, whether glucose is present or not, the adenosine triphosphate lost by the Crabtree effect being balanced by that gained by aerobic glycolysis. The facts indicate that the following relation holds :

$$\{Q_{\rm O_2} - Q_{\rm O_2}({\rm G})\} \times 2\frac{\rm P}{\rm O} = Q_{\rm CO_2}({\rm O_2})$$

where P/O = 3, and that, therefore, respiration and phosphorylation in the intact tumour cell are tightly coupled.

(2) The efficiency with which the tumour cells under investigation incorporate glycine, under aerobic conditions, into their proteins as a result of availability of adenosine triphosphate is the same in the absence of glucose as it is in the presence of glucose. The efficiency term is defined by the ratio $A/Q_{\rm ATP}$, where A is the radioactive amino-acid incorporated into the tumour protein (given in counts per minute per milligram dry-weight protein) and $Q_{\rm ATP}$ is the available adenosine triphosphate calculated as equal to $6Q_{\rm O_2}$ under aerobic conditions in the absence of glucose or to $6Q_{\rm O_2} + Q_{\rm CO_2}({\rm O_2})$ in the presence of glucose, or to $Q_{\rm CO_2}({\rm N_2})$ anaerobically in the presence of glucose. The energy released by tumour respiration, in the absence of glucose, calculated on the basis of P/O = 3 for the tumour cell, is quantitatively as effective for amino-acid incorporation into tissue proteins as the respiratory energy of rat embryo.

(3) The efficiency of glycolytic energy for incorporation of amino-acid into tumour proteins is approximately equal to, though usually a little higher than, that of respiratory energy.

(4) A survey of the relative rates of incorporation of glycine-1-^{14}C into the proteins of a variety of tissues under aerobic and anaerobic conditions, glucose being present, shows : (*a*) The highest efficiency ratios, both aerobic and anaerobic, occur with the most rapidly proliferating tissues, namely, tumours and embryos. Thymus and pancreas, among normal mammalian tissues, have the highest aerobic efficiencies. (*b*) The ratio of anaerobic efficiency to aerobic efficiency approximates to unity with tumours, the anaerobic value being usually a little higher than the aerobic. With adult rat tissues, and with chick and rat embryos, the aerobic efficiency term usually exceeds the anaerobic value. (*c*) A number of normal tissues (for example, kidney medulla, retina), having relatively high anaerobic glycolytic rates, have little or no anaerobic efficiencies for the incorporation of glycine into their proteins. It would seem that extra mitochondrial, or cytoplasmic, adenosine triphosphate (made available by glycolysis) cannot be used in these tissues for amino-acid incorporation. This is to be contrasted with the efficiency of embryonic energy made available by anaerobic glycolysis. Many adult mammalian tissues show relatively low aerobic efficiency terms for amino-acid incorporation, as compared with those of tumour or embryo.

(5) Essentially similar results are obtained with tumour and embryo using phenylalanine-2-^{14}C instead of glycine-1-^{14}C.

(6) Tumours and embryos, which resemble each other in their high aerobic and anaerobic efficiency terms for amino-acid incorporation into their proteins, differ in their relative responses to the effects of malonate in the absence and presence of glucose. Although malonate greatly inhibits both respiration and incorporation of amino-acid into proteins of Ehrlich ascites cells and of chick embryos, the addition of glucose almost eliminates the malonate inhibition with the tumour cells, but has little or no effect on the malonate inhibition with chick embryo.

(7) Bilirubin, at low concentrations, suppresses incorporation of glycine into Ehrlich ascites cells. It acts as an uncoupling agent, and, like dinitrophenol, abolishes the Crabtree effect. Its inhibitory effect on amino-acid incorporation is partially reversed by glucose, which may play an important part in enabling a tumour cell to withstand the toxic effects of certain metabolic poisons.

We gratefully acknowledge financial support of this work by the National Cancer Institute of Canada and by the Cancer Research Soc. Inc.

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THE FISH CULTURE RESEARCH STATION, MALACCA

By Dr. C. F. HICKLING, C.M.G.
Acting Director

FISH culture has the same object as agriculture and stock breeding, namely, to increase by all possible means the production of food far above the level which would be produced naturally. Like agriculture, fish culture includes the elimination of unwanted plants and animals, their replacement by desirable species, the improvement of these species by cross-breeding and selection, and the improvement of the substratum by the use of fertilizers.

The remarkable rate of increase of human populations is bringing increasing pressure on food production. In Malaya, for example, the population will, on present trends, double every twenty years. It is widely realized that every possible piece of suitable land must be brought into production, and great efforts are being made to do so. No less must every suitable piece of water produce the maximum weight of fish.

But whereas fundamental research in tropical agriculture does not lack research stations of the first magnitude, there has so far been lacking a research station, on the scale of a major agricultural station, for the fundamental study of fish culture. The Fish Culture Research Station at Batu Berendam, Malacca, was designed to fulfil this need. Its function may be briefly described as to give a new look to an ancient and stereotyped traditional technique.

The Station was built at a cost of some £235,000 to Colonial Development and Welfare Funds, and was officially opened on August 21, 1957, ten days before Malaya attained independence. The Station is intended to serve, in the first instance, all tropical Commonwealth territories; and so the problems it will tackle will be such as are common to all, or most of, these territories. It is intended to accept contributions from all such territories as are willing to support this work.

Batu Berendam is nearly five miles north-west of Malacca, on first-class tarmac roads; and the Station has municipal piped water and electricity. Besides the laboratory building, there are six houses for senior staff adjacent, and fourteen quarters for junior staff. The pond area is only some 400 yd. from the laboratory.

The Station is at approximately sea-level; there is no seasonal variation in either temperature or rainfall. Rainfall averages about 100 in. a year; air temperature varies but little from a diurnal range of 76–86° F.

The laboratory (Fig. 1) is a one-story building of modern design, with six working rooms in addition to offices, workshops and stores. There is research accommodation for eight scientists; as the establishment of the Station is for a director and five scientific officers, there is accommodation for visiting workers, who will be very welcome. The laboratory has been designed for extension as required.

Novel features of the laboratory are, first, an underground rain-water tank, from which rain-water collected from the roof is automatically pumped to a cistern at the top of the tower seen in Fig. 1, to descend by gravity through polyethylene piping to thirty-six concrete tanks, in which fish can be held for quarantine or examination, and in which they can be bred. Secondly, eight similar concrete tanks are in a blacked-out compartment with powerful 'daylight' lighting. An automatic time-switch enables fish or plants in this compartment to be subjected to whatever number of hours of 'daylight' an experiment requires. Interesting results might come from subjecting tropical fish, which know no seasonal variation in their length of day, to temperate lighting conditions.

The estate in which the fish-ponds are constructed is 170 acres of former swamp land; of these, 82 acres are actual water surface. There are 164 ponds, of a size ranging from breeding ponds of 1/100 acre, to ponds of 4½ acres. A unique feature of the Station is that, within each group, the ponds are identical in shape, area and depth. Fig. 2 shows some of the ponds.

The pond site is mainly composed of a heavy lateritic clay. This is an infertile acid soil with impeded drainage, which supports crop plants with difficulty, even after the addition of fertilizers. That part of the estate which has not been used for the construction of ponds is still largely swamp land and supports a stand of 'gelam' trees. These trees are known to grow well on land which proves sterile and often toxic when afterwards prepared for agricultural use. The harmful nature of such soils may be caused by a high concentration of soluble sulphates and aluminium salts which have been found to be present[1]. Seepage water from swamp land adjacent to the fish-ponds was analysed, and contained more than 0·1 per cent of sulphate and more than 6 p.p.m. of aluminium. This affects the pond water-supply, which is taken from the Malacca River (pH 6·0, sulphate negligible). After flowing through the canal, water taken at the pump house, which supplies the ponds, has a pH of 3·5 and contains more than 60 p.p.m. of sulphate.

Similar toxic effects, resulting from the drainage of swamp land, have been frequently reported (for example, in Uganda[2]). In spite of considerable agricultural research, the problem of using such land profitably remains largely unsolved. By using such land for fish culture, therefore, the Fish Culture Research Station at Malacca is doing pioneer work. Already it has been found that heavy crops of fish, including the Chinese grass carp, can be carried, apparently in perfect health and with rapid growth, in ponds constructed in 'gelam' soil. The effect of lime dosages will be given below.

The natural production of wild fish in such poor conditions is very low. Nine of the ponds belonging to the Station, which had had standing water in them for at least two years and still had the original

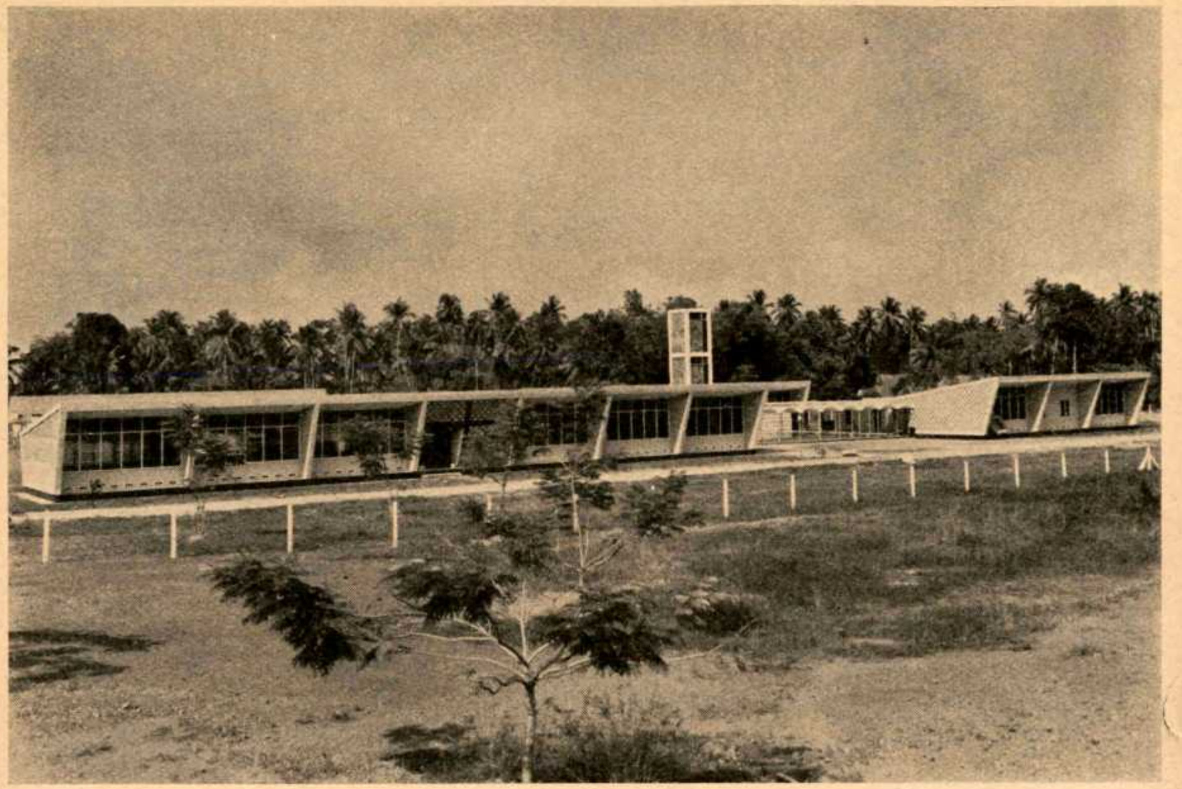

Fig. 1. The Fish Culture Research Station, Malacca

swamp-fish fauna, were cleared by the use of a suitable fish toxin, and the total fish population weighed. The average standing crop was 18 lb. per acre, comparable with the annual production of the fresh-waters of England and Wales, of Lake Tiberias in Palestine, and of Lake Mendota in Wisconsin[3].

By clearing away swamp vegetation, liming to neutrality, and stocking with desirable species, already yields at a rate of more than 300 lb. per acre per annum have been obtained, without the use of fertilizers, in these ponds.

Naturally, the work of the first year has been chiefly concerned with clearing the swamp vegetation from the ponds, and breeding stocks of fish to put in them. Nevertheless, a full-scale experiment has been carried out, in the thirty-six 1-acre ponds, on the effect of six levels of lime dosage each replicated six times, from zero to 2 tons per acre. In Fig. 3 is shown the effect on the *p*H of these successive doses. Each point is the mean for six ponds. It will be seen that the untreated controls had a *p*H of 5, and that the *p*H rapidly increased with increasing lime dosage until, after about 15 cwt. limestone per acre, the *p*H levelled out at about neutrality.

This quantity, namely, 15 cwt. limestone per acre, appears to be much less than that quoted by the text-books. Most authors follow Schäperclaus, who himself copied agricultural tables by Trenel. From Schäperclaus's table, heavy loams or clays, such as exist at the Station, of a *p*H of 4·5–5, would need 25 cwt. lime per acre, or say 50 cwt. chalk. The table published by Macan, Mortimer and Worthington[5] would prescribe 18–36 cwt. limestone per acre. However, these experiments at Malacca are the first, so far as I know, to be done on the large scale in conditions of very acid soil and water.

This work is continuing with an investigation of the effect on fish production of graduated doses of phosphate and potash, with and without limestone. The final object of this line of work is to increase the fish crop with the least expense, by using the best ascertained fertilizer mixture.

The changes in vegetation consequent on the clearing of the swamp vegetation, flooding with water, and the application of lime in various doses, have provided an interesting study.

From typical swamp consisting mainly of sedges, flooding alone tends to eliminate only short plants such as *Eriocaulon* and *Xyris*. The addition of lime, as well, suppresses the growth of *Rhynchospora aurea*, *Scleria poaeformis* and *Philydrum lanuginosum*, leaving *Fimbristylis acuminata* and *Isachne globosa* comparatively unaffected. These latter disappear only with regular cutting. As a result of liming, the typical lime-lover *Chara flexilis*, originally not present in the area, appeared and spread, especially after the draining and refilling of the ponds. The disappearance of emergent vegetation was followed by an increase in planktonic algae, except in those ponds where there were dense beds of *Chara*. No doubt, in these latter, intense competition for available salts suppresses the growth of the algae. Ponds with unstable bottoms and muddy water differed in that both submerged macrophytes and planktonic algae tended to be suppressed, probably due to the extreme turbidity of water. There is some evidence that in limed ponds, submerged macrophytes, particularly *Chara*, give way eventually to beds of *Enhydrias angustipetala*, and this process is hastened by the application of artificial fertilizers such as potassium chloride – ammonium phosphate mixture, which is being tried out.

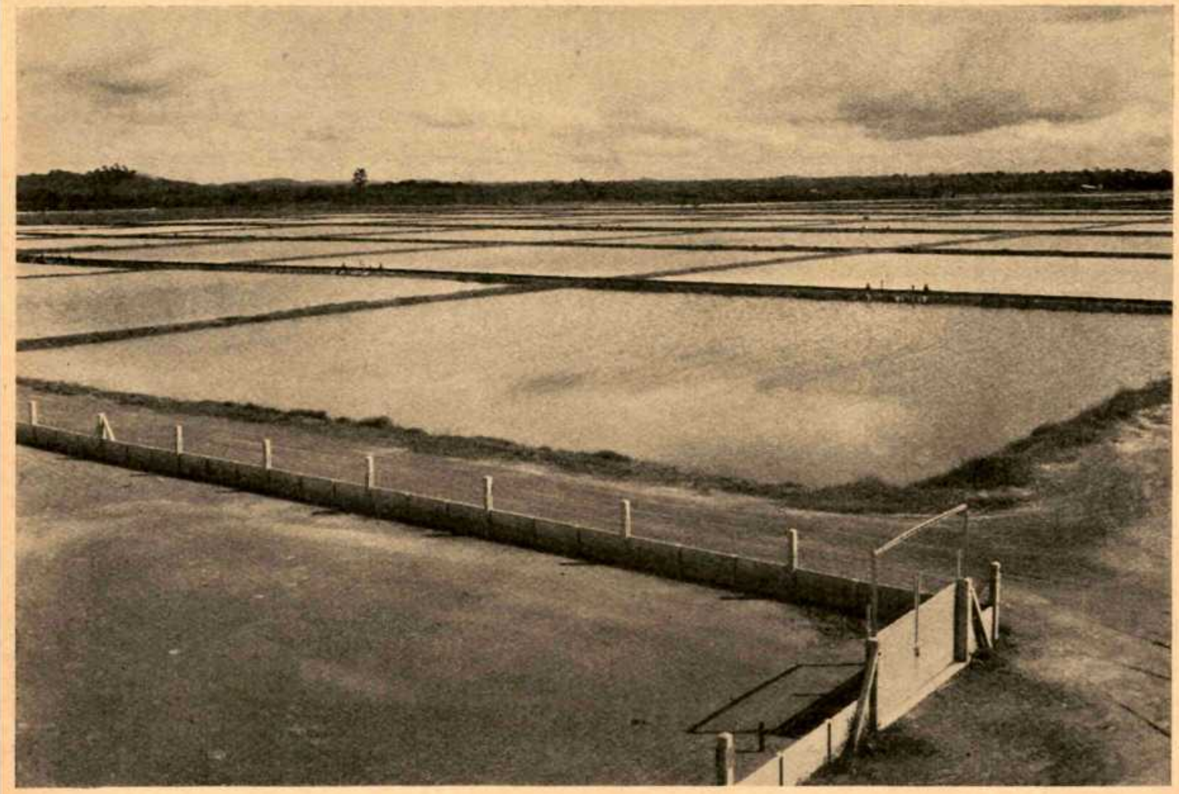

Fig. 2. Fish ponds at the Fish Culture Research Station, Malacca

As yet, a study of fodders, to supplement the food naturally produced for the fish in the ponds, has not passed beyond a preliminary study of the digestive enzymes of fish, and of that part of the natural food which is utilized by the fish. But undoubtedly this work will lead on to a study of cheap fodders, chiefly oil-cake residues, and finding out what part of these can be utilized. The final object of this line of work would be something approaching a balanced ration, taking into account not only the added fodder, but also the natural food supply. This has been done for fish-ponds in temperate climates, but not under tropical conditions.

The Station holds stocks of the following species: *Tilapia zillii* from East Africa; *T. mossambica*, local; *Tilapia* sp. from Zanzibar and hybrids of these *Tilapia* species; *Cyprinus carpio*, common carp, local; *Puntius javanicus*, supplied by the Fisheries Department of the Federation of Malaya; *Catla catla*, from Calcutta; *Osphronemus olfax*, the giant gouramy, local; *Trichogaster pectoralis*, Sepat Siam, local; *Ctenopharyngodon idellus*, the Chinese grass carp, from China.

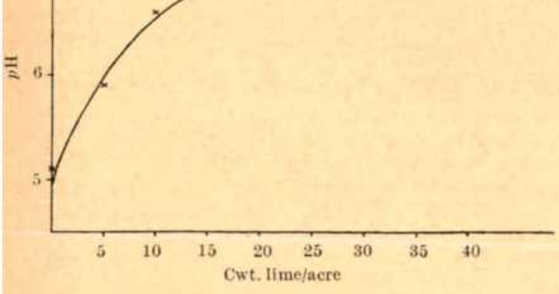

Fig. 3. Effect of lime on pH. Approximate conditions after 100 days

Stocks of the last-named fish are being held against the visit of Dr. H. D. Slack, who, on the basis of work now being carried out by him in the Department of Zoology, University of Glasgow, supported out of Colonial Development and Welfare Funds and by the Nuffield Foundation, hopes to induce them to spawn in captivity. This valuable fish has never spawned in fish-ponds; the fry have to be imported, chiefly from Canton.

Chief interest at present centres on the *Tilapia* hybrids. The Malayan stock of *Tilapia mossambica* is very inbred, and the cross with new stock from East Africa not only has, as might be expected, great vigour and strength; but also certain crosses give a very skew sex-ratio, indeed up to 100 per cent males; and a marking experiment just ended indicates that the cross-bred fish may grow twice as fast as either the Malayan or the African parent stocks. An extremely promising field is open here; for a fish of very rapid growth, but which cannot breed in the rearing ponds, comes very close to the ideal pond-fish for commercial or subsistence raising.

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OBITUARIES

Prof. Niels Bjerrum

We regret to record the recent death of Niels Bjerrum. He was born in Copenhagen on March 11, 1879, and studied in the University there, taking the degree of Dr. Phil. in 1908 and presenting a dissertation on the hydrolysis of chromium compounds. This work was extended by the discovery of the third isomeric hexahydrate of chromic chloride and, as a result of a study of the absorption spectra of solutions of chromic salts, by the provision of an experimental foundation for the hypothesis of the complete dissociation of strong electrolytes in solution, which Bjerrum in 1909 was the first to make really significant.

Bjerrum later published many valuable researches in various branches of electrochemistry, the theory of acids and bases, the measurement of hydrogen ion concentrations, amphoteric electrolytes, and the behaviour of indicators. He published a monograph on acid-alkali titration and discovered a simple method of eliminating diffusion potentials in measurements of hydrogen ion concentrations. His work in this field had a very significant influence on the development of the modern theory of electrolytes. He developed a simple equation connecting the activity and osmotic coefficients of an electrolyte, and another one relating the activity coefficients to reaction velocity. He worked with Perrin in 1911 on the Brownian movement and later published work on colloid chemistry. In 1923, he published an important paper on the relation of the stages of ionization of polybasic acids to the molecular structure. In 1911, he related the specific heats of steam and carbon dioxide to band spectra. In 1912, he published work with Nernst on the specific heats of steam and carbon dioxide at high temperatures as determined by the explosion method, and in 1914 he laid the foundations of the theory of the infra-red spectra of polyatomic molecules by introducing the so-called valency force-field, which has led to all subsequent developments in this subject. In these publications he applied the newly developed quantum theory of specific heats to gases.

In 1914, Bjerrum became professor of chemistry in the Royal Danish Veterinary and Agricultural College in Copenhagen, an institution which has had a distinguished history. Since then he has published a large amount of important work in various branches of inorganic and physical chemistry and on problems in agricultural chemistry, notably on the factors which determine the *p*H of soils and their fertility. He wrote an excellent small text-book on inorganic chemistry which has gone through several editions, including two in an English translation.

In his prime, Niels Bjerrum was a tall man of handsome presence with an open and friendly expression, and a calm dignity of manner. He will be greatly missed by his many friends in all parts of the world.

J. R. Partington

Prof. D. C. Grahame

David Caldwell Grahame, professor of chemistry at Amherst College, Amherst, Massachusetts, U.S.A., died suddenly as a result of a coronary thrombosis in London on December 11. He was spending the academic year as a visiting professor in the University of Bristol.

Prof. Grahame was born in St. Paul, Minnesota, on April 21, 1912. He received a bachelor's degree in chemical engineering at the University of Minnesota in 1935 and a Ph.D. degree in physical chemistry at the University of California at Berkeley in 1937. From then until 1939 he was an instructor in chemistry at Berkeley. From 1939 he was on the staff at Amherst College, becoming assistant professor in 1942, associate professor in 1947 and professor in 1953. He received an honorary M.A. from Amherst in 1953. In 1945 he was a member of the staff of the Radiation Laboratory, Massachusetts Institute of Technology. He taught at Harvard in the summer of 1948. He had visited Europe on several occasions since 1952, having been invited to present papers at meetings of the Deutsche Bunsengesellschaft (1955) and the Chemistry Section of the Soviet Academy of Sciences (1956). He held a Guggenheim Fellowship during his stay in Bristol.

His scientific work was largely in the field of electrochemistry, particularly in the study of the electrical double layer located at the interface between a metal and an electrolytic solution. He developed an accurate method of determining the properties of this double layer by measuring its electrical capacity with an alternating current bridge using a growing drop of mercury or gallium as electrode. With this elegant technique he obtained precise results for an extensive variety of electrolytes. Starting from the basic thermodynamic principles, he showed how these results could lead to accurate values of the ionic concentrations at the surface of the electrode and hence to a reliable picture of the structure of the interfacial region. He gave a lucid and comprehensive account of the theory of this procedure in *Chemical Reviews* in 1947, which was further developed in his paper with Barbara Sodernerg in the *Journal of Chemical Physics* in 1954.

More recently, Prof. Grahame had turned to the adsorption of poly-electrolytes and the use of non-aqueous solutions. In recent months he had devoted much attention to a study of the distribution of potential in the region within a few Ångströms of the surface of the metal. The progress he made in elucidating the latter was only possible on the basis of the precise experimental work in which he excelled, together with the depth of his insight into the theoretical aspects of the problem. It is regrettable that this work remains incomplete.

David Grahame's cheerful friendliness won him friends in all parts of the world, all of whom must grieve at his early death. He was married in 1935 to Virginia Dakin, who survives him, with a son and a daughter.

R. Parsons

Prof. William Brunner

On December 1 William Brunner, emeritus professor of astronomy in the University of Zurich and the Swiss Federal Institute of Technology, died in Zurich. Brunner was born in Wattwil (Switzerland) on July 8, 1878. In 1900—after having been a merchant for some years—he began studying astronomy at the Swiss Federal Institute of Technology in Zurich, where in 1904 he acquired the diploma in mathematics and physics. During the next twenty-two years he was a teacher in a girls' college, until in

1926, in succession to Prof. A. Wolfer, he was appointed director of the Swiss Federal Observatory and at the same time professor of astronomy in the Institute and in the University of Zurich; both directorship and professorship he occupied until, for reasons of health, he retired in 1945.

Besides lecturing, Brunner carried on the traditional work of the Swiss Federal Observatory, namely, the observation of sunspots. In thirty numbers of the *Astronomische Mitteilungen* and in two volumes of the *Publikationen der Eidgen. Sternwarte* he published the yearly reports on solar activity, which contain above all the relative sunspot numbers as a continuation of the series reaching back to the year 1749, but also articles on the development of sunspot groups and on the prominence statistics. In 1928 the International Astronomical Union handed over to him the publication of the *Quarterly Bulletin on Solar Activity*. During the years 1938–45 he was a member of the executive committee of the International Astronomical Union.

Brunner wrote several popular books, among them "Die Welt der Sterne" and "Pioniere der Weltallforschung". On his retirement in 1945 he was elected an Associate of the Royal Astronomical Society of London.

M. WALDMEIER

NEWS and VIEWS

Forestry Division of the Food and Agriculture Organization: M. Leloup

M. MARCEL LELOUP, director of the Forestry Division of the Food and Agriculture Organization of the United Nations since its creation twelve years ago, is retiring. M. Leloup was a veteran of the First World War and a recipient of the Légion d'Honneur after losing an arm during the battle of Verdun. Having graduated from the famous École Polytechnique, he began his forestry career with the Colonial service of the French Department of Waters and Forests in French Equatorial Africa. In 1932 he returned to Paris to the general direction of the Department of Waters and Forests. In 1936 he was assigned to the Presidence du Conseil and charged with several special missions concerning agricultural and administrative matters. It was in this capacity that he collaborated in the establishment of the Statute of Public Function and was nominated to the highest French administrative body, the Council of State. After the Second World War, M. Leloup became director-general of the Department of Waters and Forests and a Councillor of State. Shortly afterwards he was a member of the French delegation to the Quebec conference of 1945, at which the Food and Agriculture Organization was founded. In May 1946 he became the first director of its Forestry Division. The wide organizational work which he accomplished in this capacity gave him an exceptional knowledge of the problems and possibilities of forests in the world, and he was active in the formation of the Regional Forestry Commission for Europe (1947), for Latin America (1948), for Asia and the Far East (1949) and for the Near East (1953).

E. Glesinger

MR. EGON GLESINGER, formerly deputy director, became director of the Division of Forestry and Forest Products, the new title of the Forestry Division, on January 1. Mr. Glesinger was born in 1907 and was educated in Austria and Czechoslovakia. He graduated in commercial science at Geneva in 1927, obtained a doctorate of law at Prague in 1929 and a doctorate in political science at Geneva in 1932. He also studied at the Institute for International Studies at Geneva, and his thesis on European forests was afterwards published in book form. During 1933–38, Mr. Glesinger was director of the International Timber Committee, an organ of the League of Nations situated first in Vienna and later in Brussels. After the Second World War, he served on the Interim Commission which preceded the formal establishment of the Food and Agriculture Organization, and has been an official of the Organization since its foundation. Besides his post as deputy director of the Forestry Commission, he is at present director of the Timber Division of the United Nations Economic Commission for Europe.

Canadian National Aeronautical Establishment

THE creation of a new Division of the National Research Council of Canada, to be known as the National Aeronautical Establishment, has recently been announced. The formation of the National Aeronautical Establishment was initially authorized in 1951, when it consisted of the aeronautical research facilities of the Division of Mechanical Engineering in the National Research Council, but the heavy and increasing demands on the Establishment have rendered it administratively expedient to separate it from the present Division of Mechanical Engineering, and embody it in a separate Division. The resources of the new Division will consist of the Flight Research Hangar and laboratories at Uplands Airport, the new 5-ft. supersonic wind-tunnel now being constructed at Uplands Airport, and the Aerodynamics and Structures Laboratories in the Montreal Road Laboratories of the National Research Council. The new Establishment will work on defence problems in aeronautical science, and will also be responsible for meeting the aerodynamic and structural research needs of civil aviation and of the aircraft industry.

Mr. F. R. Thurston

MR. FRANK R. THURSTON, head of the Structures Laboratory of the Division of Mechanical Engineering, who has been appointed acting director of the National Aeronautical Establishment, was educated in the United Kingdom, graduating from the University of London. He went to the National Research Council in 1947 from the National Physical Laboratory, Teddington, where he worked on supersonic aerodynamics and on the structural design of aircraft. In the National Research Council he has been responsible for the structural proving of prototype Canadian-built aircraft, and for a wide range of research on structural fatigue, towers and shell structures, and aircraft hydraulic equipment. Representing Canada, Mr. Thurston is chairman of the

Structures and Materials Panel of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization and works as a co-ordinator for the Commonwealth Advisory Aeronautical Research Council.

Royal Geographical Society : Medals and Awards, 1959

H.M. THE QUEEN has approved the award of the Royal Medals of the Royal Geographical Society, as follows: *Patron's Medal:* Commander W. R. Anderson, U.S.N., for the first trans-polar submarine voyage, in command of U.S.S. *Nautilus*; *Founder's Medal:* Sir Raymond Priestley, British observer, U.S. Antarctic Expedition, 1958–59, for services to Antarctic exploration.

The Council of the Royal Geographical Society has made the following awards: *Victoria Medal:* Mr. Gerald Seligman, president of British Glaciological Society, for contributions to glaciological research; *Murchison Grant:* Prof. S. P. Chatterjee, professor of geography, Calcutta, for important work organizing and directing the "National Atlas of India"; *Back Grant:* Mr. David Stratton, deputy-leader, Commonwealth Trans-Antarctic Expedition; *Cuthbert Peek Grant:* Mr. W. George Lowe, for contributions to Himalayan and Antarctic exploration; *Gill Memorial:* Mr. G. S. Holland, chief draughtsman, Royal Geographical Society, for contributions to cartography, especially of southern Arabia; *Mrs. Patrick Ness Award* (jointly): Mr. J. H. Miller, deputy-leader, New Zealand party, Commonwealth Trans-Antarctic Expedition, for contributions to Antarctic exploration, and Dr. George W. Marsh, Commonwealth Trans-Antarctic Expedition and Falkland Islands Dependencies Survey, for contributions to Antarctic exploration.

British National Committee on Antarctic Research

THE British National Committee on Antarctic Research has been set up to co-ordinate British Antarctic activities in relation to the large scientific programme at present being considered by the Special Committee on Antarctic Research of the International Council of Scientific Unions. This programme includes meteorology, ionospheric studies, auroral physics, geomagnetism, cosmic rays, geology, glaciology, geomorphology, cartography, seismology, gravity, vulcanology, oceanography, sea ice, biology including marine aspects and physiology. The members of the new National Committee are: *Chairman*, Sir Raymond Priestley; Royal Society: Prof. W. V. D. Hodge, Sir Lindor Brown, Dr. H. G. Thornton, Mr. A. H. Sheffield, Prof. F. W. Shotton, Prof. J. E. Smith, Dr. R. L. Smith-Rose, Dr. R. Stoneley and Sir James Wordie; Sir Vivian Fuchs, scientific director, Falkland Islands Dependencies Survey; Brig. M. Hotine, director, Overseas Surveys; Rear-Admiral K. St. B. Collins, hydrographer of the Navy; Dr. G. E. R. Deacon, director, National Institute of Oceanography; Sir Graham Sutton, director-general, Meteorological Office; Dr. G. de Q. Robin, United Kingdom delegate to the Special Committee of Antarctic Research; Sir Miles Clifford, Royal Geographical Society; Dr. E. Hindle, Royal Geographical Society; Mr. G. Seligman, British Glaciological Society; Dr. S. Evans, Scott Polar Research Institute; Mr. J. Paton, Royal Society of Edinburgh; Dr. L. G. C. E. Pugh, Medical Research Council; and Mr. H. H. Lamb, Royal Meteorological Society.

Safety and the Nuclear Power Industry

THE hazards which nuclear power stations present were raised by Mr. G. Roberts in an adjournment debate in the House of Commons on January 21. In reply, Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, said that on the best evidence available there is no danger of radioactive strontium from nuclear power stations in areas of high rainfall like north-west Wales adversely affecting the water supply. Further, although the amount of radioactive strontium descending from the stratosphere is increasing at the present rate, it will be several generations before the equilibrium-level built up in the bones of the population reaches the amber band. The increase in leukæmia began a generation before the first nuclear tests, and there are at present no statistically significant differences, either by area or in time, in the incidence of this disease; specifically there is no statistical difference between north Wales and other parts of the United Kingdom. In the normal operation of a nuclear power station certain radioactive substances might go up the stack but their life is so short that they can be ignored, as can seepage. As regards the release of coolants, monitoring is done with such extreme care that hazard is unlikely. The Wigner type of release which led to the Windscale accident will not be necessary in the new stations where the coolant, carbon dioxide, will operate in a closed circuit. Sir Ian thought that only in very exceptional circumstances could an accident lead to serious contamination and assured the House that Britain is in the forefront not only of constructional ingenuity but also in safety devices in this field.

Glass in Nuclear Research

IMPORTANT developments in nuclear research in recent years have meant an increased demand for viewing windows to permit clear observation of operations or objects within the bounds of the 'hot' cell walls, and also to facilitate the remote handling of radioactive materials, while providing protection for the operatives. Just as ingenious mechanisms have been evolved for remote handling, so have special types of glass been produced for shielding windows. The Chance-Pilkington Optical Works, at St. Asaph, North Wales, has now developed radiation-absorbing glasses of larger dimensions than have been available hitherto in Europe. Particularly at very short wave-lengths, the attenuation offered by protective walling is proportional to the density of the material employed. The Chance-Pilkington shielding glasses range in density from 2·5 gm. per c.c. to 6·1 gm. per c.c., and allow the design of windows to be, in many cases, of equal thickness to the surrounding wall, thereby reducing the complexity of additive shielding and obtaining the maximum optical advantage from the window.

Upon receipt of large doses of short wave-length radiation, glasses of normal composition tend to discolour to a deep yellow or brown. To overcome this, Chance-Pilkington manufacture a series of glasses which are stabilized. These glasses have amended compositions having the effect of slightly decreasing the transmission of the glass in the unirradiated state, but reducing the tendency for further discoloration under conditions of radiation. Shielding glasses of density 2·5 gm. per c.c. and 4·3 gm. per c.c. are manufactured in polished plate form and also in block form up to 4 ft. 6 in. by 3 ft. in area and 10 in. in thickness, with the limitation for the time being that no single block shall weigh more than 2,000 lb.

New Process of Making Plate Glass

PILKINGTON BROTHERS, LTD., of St. Helens, Lancashire, have just announced the successful development of a new process of making plate glass. In the new process the plate glass is produced with a fire-polished finish, so that the lengthy grinding and polishing operations which are necessary with the present method of producing plate glass are eliminated. The crux of the process which contains the revolutionary idea is that the molten ribbon of glass, which flows from the usual tank furnace containing the molten glass through a pair of rollers, is then supported on the surface of a bath of liquid metal. This is at a sufficiently high temperature for the under-surface of the glass to take up the extreme flatness of the surface of the liquid metal while at the same time the top surface can be subjected to sufficient heat to produce a good fire polish. This new operation takes place in a chamber containing a controlled atmosphere. Pilkingtons have named the new process the 'float process' and are referring to the new product as 'float glass'. Ordinary window glass, known in the industry as sheet glass, is also produced with a fire-polished surface by drawing upwards from the surface of a bath of molten glass, but the quality of this type of glass is not sufficiently good for its use in motor-car windows, shop windows, or for the preparation of mirrors, and it is for applications of the kind just mentioned that plate glass is in demand. The growth of the motor-car industry has, of course, made the demand for plate glass rise steeply, and this invention is thus a very timely one.

The history of the manufacture of plate glass can be seen to follow a pattern in recent years of the gradual development of an existing process until a fundamentally new idea occurs. About the beginning of the first century A.D., flat glass was first made by the crown process, in which a flat disk of glass was spun on the end of an iron. The method of making sheet glass by fabricating a cylinder which was then split and flattened was first described in about A.D. 1100; the casting and rolling process of making plate glass was invented in France towards the end of the seventeenth century. In 1910 the cylinder method was mechanized and cylinders up to 40 ft. long and 6 ft. in diameter were made. Mechanical production of sheet glass by drawing flat sheets of glass directly from a tank was first effected in Belgium just before the outbreak of the First World War, and in 1920 the continuous flow process of plate glass manufacture was developed in the United States. Pilkingtons have largely been concerned in the development of this process, leading to the famous twin-grinding machine, which grinds and polishes both sides of the glass simultaneously. In the light of this background, it can be seen that this new invention is justifiably described as revolutionary.

Cambridge Instrument Co., Ltd.: New Research Laboratory

CONSTRUCTION has commenced of the new Research Laboratory for the Cambridge Instrument Co. Overlooking the River Cam and Jesus Green, and within ten minutes walk of the centre of Cambridge, the 20,000 sq. ft. building will provide an imposing frontage for the Cambridge factory. The top floor with generous roof lighting will form an ideal design and drawing office, and the three floors below are being fitted with the latest equipment for instrument work involving physics, chemistry, electronics and precision mechanical engineering. The new building heralds a considerable expansion in research, development and design for which staff are now being recruited. The architects are Messrs. Edward D. Mills and Partners, designers of the British Industries Pavilion at the Brussels Universal and International Exhibition, 1958, and Messrs. J. Jarvis and Co. are the main contractors. The new Laboratory is scheduled for completion in June.

Iron and Steel at the Science Museum

A NEW exhibition on the principles underlying the manufacture of iron and steel will be opened by Lord Mills, Minister of Power, on February 6 at the Science Museum, South Kensington. Exhibits have been drawn from the Museum's own collections and contributed by makers and users of iron and steel, by other museums and individual donors, to illustrate the development of that industry from its earliest beginnings. By far the largest contribution has been from the British Iron and Steel Federation, which has not only provided a large number of new exhibits but also financed the whole project. Only outstandingly important technological aspects and developments can be touched upon in a limited space—direct reduction of iron ore, charcoal-blast pig-iron and its fining to malleable iron, coke-iron, foundry work, puddling, crucible steel and cementation, modern blast-furnace practice, Bessemer, open hearth and alloy-steel making and modern methods of casting, forging, rolling, drawing, together with theoretical metallurgy, testing and research. The treatment is not exhaustive but provides an excellent stimulus to further study.

British Association: Granada Lectures

A NEW series of annual lectures, organized by the British Association for the Advancement of Science and sponsored by Granada TV Network, Ltd., on the theme of "Communication in the Modern World", has been announced. The broad purpose of these lectures is to explore the impact of communications in the field of the mass media—Press, radio, television and film—in their sociological, political and technical aspects. The first series of three lectures will be given in London in October 1959: the first by Sir Edward Appleton, who will speak on the significance for society of long-range communication and the exploration of space; the second by Dr. Edward R. Murrow, the American television and radio commentator and news analyst, who will speak on the impact of television and radio in the field of politics and public affairs in a democracy; the third by Sir Eric Ashby, whose subject will be methods of presenting scientific information to the man in the street and the extent to which the part played by the mass media in this field might be extended or improved. The lectures will be delivered to an invited audience, to include representatives of science, industry, politics, education, local government, the mass media and others. There will also be a limited number of tickets available to the public. The texts of the lectures will afterwards be published. With each lecture will be linked a television programme, in which it is hoped the lecturer will participate, dealing with the subject-matter of the lecture in appropriate television form for a wider audience.

Synthetic Quartz Crystals

THE Western Electric Company and the Bell Telephone Laboratories in New York have jointly succeeded in growing large crystals of artificial quartz by a process which they hope to develop on a technical scale. It has long been known that small quartz crystals can be developed in silicate solutions by suitable treatment, but in the new process crystals up to 5–6 in. long and 2–3 in. cross-section have been obtained. The method consists in filling a vertical autoclave with an alkaline solution, usually of sodium hydroxide. Small pieces of natural quartz are placed in the bottom to serve as material and high-quality sand will, it is expected, be used in future. Seed plates cut from natural or artificial quartz crystals are hung from a rack in the upper part of the vessel. After sealing, the autoclave is heated to the required temperature and maintained with a constant temperature differential from bottom to top during the processing time, which has varied from a week to several weeks. Growth occurs primarily in one dimension and flat plates are used, which become thicker but change little in other dimensions. The nutrient material dissolves in the hotter lower region and is carried by convection currents to the cooler upper region, where the solution becomes supersaturated and the dissolved silica is deposited in the form of a single crystal. The combination of conditions of high temperature and pressure in the autoclave is severe and the effective sealing of the autoclave has presented a number of problems in the selection of material and design. The crystals produced have no foreign inclusions, can be obtained without optical or electrical twinning, and can be sawn in the most efficient manner.

The Night Sky in February

NEW moon occurs on Feb. 7d. 19h. 22m. U.T., and full moon on Feb. 23d. 08h. 54m. The following conjunctions with the Moon take place: Feb. 2d. 01h., Jupiter 3° S.; Feb. 4d. 12h., Saturn 4° S.; Feb. 16h. 05m., Mars 6° N. Mercury is too close to the Sun for observation. Venus is an evening star, visible in the south-west after sunset. It sets at 18h. 30m., 19h. 10m. and 19h. 55m. on February 1, 15 and 28, respectively; its stellar magnitude is $-3{\cdot}3$. Its distance decreases during the month from 146 to 137 million miles, and the visible portion of the apparent disk decreases from 0·945 to 0·900. Mars is moving eastwards among the stars and is in Taurus during February. It sets at 2h. 45m., 2h. 25m. and 2h. 05m. at the beginning, middle and end of the month, respectively. Its stellar magnitude decreases from $+0{\cdot}3$ to $+0{\cdot}8$, its distance from the Earth increasing from 94 to 119 million miles. Mars is well placed for observation during the evening. Jupiter rises at 2h. 45m., 2h. 00m. and 1h. 10m. on February 1, 15 and 28, respectively; it is in Libra. The stellar magnitude of Jupiter is $-1{\cdot}6$; conditions for observation are not very favourable. Saturn is a morning star in Sagittarius, rising at 5h. 35m., 4h. 45m. and 3h. 55m. at the beginning, middle and end of the month, respectively. It is unfavourably placed for observation. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Feb. 17d. 21h. 43·6m., 115 Tau. (*D*); Feb. 18d. 18h. 20·9m., 124 H^1 Ori. (*D*); Feb. 20d. 0h. 23·0m., λ Gem. (*D*); Feb. 21d. 19h. 14·2m., α Cnc. (*D*). *D* refers to disappearance.

Announcements

SIR JOHN COCKCROFT has accepted the invitation of his fellow Trustees of the future Churchill College, Cambridge, to become its first Master. Future Masters of the College will be appointed by the Crown on the advice of the Prime Minister.

LIFE peerages (baronies) have been conferred on the following: Sir Eric James, high master of Manchester Grammar School; Sir Edwin Plowden, chairman of the United Kingdom Atomic Energy Authority; Prof. Lionel Robbins, professor of economics in the University of London; and Sir Hartley Shawcross, the distinguished lawyer.

PROF. R. G. BASKETT has been appointed director of the National Institute for Research in Dairying, University of Reading, as from August 1, 1959.

DR. T. S. ENGLAND has been appointed head of airborne radar at the Royal Radar Establishment, Malvern, as from January 1.

THE New York Academy of Medicine has awarded its Medal to Dr. Peyton Rous for his contributions to knowledge of neoplastic disease. The Academy has awarded its Plaque to Mr. Montgomery B. Angell, for outstanding service to the New York Academy of Medicine as its legal adviser.

THE first of the new afternoon lectures for sixth-form children from schools in London and the Home Counties were delivered at the Royal Institutio Albemarle Street, London, W.1, on January 27 and 2 by Mr. E. Jenkins (Atomic Energy Research Establishment, Harwell), who spoke on "Radioactive Elements". This lecture is to be repeated on February 3 and 4. The programme of lectures for the remainder of the term is as follows: "The Origin of Man", by Prof. J. Z. Young, on February 10, 11, 17 and 18; "The Significance of Colour in Inorganic Chemistry", by Prof. R. S. Nyholm, on February 24 and 25 and March 3 and 4 (sponsored by the Salters' Company); "Electrons in Solids", by Prof. R. King, on March 10, 11, 17 and 18 (sponsored by the Bell Telephone Laboratories).

THE American Society of Mechanical Engineers, in co-operation with Purdue University Thermophysical Properties Research Center, is organizing a symposium on "The Thermal Properties of Gases, Liquids and Solids", to be held at Purdue University, Lafayette, Indiana, during February 23–26. Further information can be obtained from Prof. R. A. Olsen, School of Mechanical Engineering, Purdue University.

THE Seventh Latin American Congress of Chemistry will be held in Mexico City during March 29–April 3. On the afternoons of April 1 and 2 an international symposium will be held on "Recent Progress in Organic Chemistry". The morning sessions during these two days will be devoted to about twenty shorter papers dealing with steroids and related natural products. Further information can be obtained from Dr. Alberto Sandoval, Instituto de Quimica, Ciudad Universitaria, Mexico 20, D.F.

ERRATUM. Dr. S. Bricteux-Grégoire states that there was a mistake in the manuscript entitled "Utilization of Formate for the Biosynthesis of Glycine Carbon-1 and -2 in *Bombyx mori*", published in *Nature* of November 29, p. 1515. In Table 1, for "C-1, 20,300 and C-2, 43,500", read "C-1, 43,500 and C-2, 20,300".

ZOOLOGY IN NIGERIA

ECOLOGY OF LAGOS LAGOON

THE University College of Nigeria has achieved a standing among the university institutions of the Commonwealth which few even among the most visionary spirits would have dared to hope for at the time of its foundation little more than ten years ago in a forest clearing at Ibadan. Students recruited from a country where there are few secondary schools have been enabled to pursue courses for honours degrees in a wide range of subjects and disciplines within the Faculties of Arts, Science, Agriculture and Medicine, and the standards achieved by them are those which the University of London, with which the College is in special relationship, requires of its honours students. That the College should have produced a body of graduates ready to take their places as administrators and teachers in a country soon to achieve independence is a tribute alike to the innate abilities of the Nigerian student and to the sound and imaginative teaching of the professors and lecturers who, over the years, have staffed the several departments of the College. Nor in these formative years has the prosecution of research been neglected and there has recently been published, in the *Philosophical Transactions of the Royal Society*, a series of papers[*] by Prof. J. E. Webb (two of them jointly with Dr. M. B. Hill), of the Department of Zoology, which will exemplify the kind of work which is being done and which, while born of and descriptive of West African conditions, probes deeply and with discernment into problems of fundamental and more general biological interest.

The papers are concerned primarily with the life-history and ecological requirements of the Nigerian lancelet, *Branchiostoma nigeriense* Webb, one of the many species contained within the group of the Cephalochordata the structure and development of which show them to stand very close to the ancestral stock of the vertebrates. The observations range in their scope from considerations of physical geography and coastal morphology to an analysis of the significance to animals of the size and shape of sand grains, without, however, ever losing its essential unitary character as an ecological investigation.

Lagoon systems occur on the Guinea Coast, within the general areas of the Ivory Coast, Togoland and Dahomey–Western Nigeria. They are formed behind barrier beaches of sand, the sand drifting from west to east along the beaches and offshore under the action of obliquely breaking waves developed under the predominantly south-westerly winds. Lagoons are formed by the seaward advance of the barrier beach or by enclosure by outwardly growing spits curved at the tips to form offshore bars. The lagoons may remain filled with water by virtue of river drainage or access to the sea. There is, however, a tendency for them gradually to fill with sediment, first to become swamps and then dry land. Aerial photographs show that the cycle has been repeated many (about twenty) times in the 25,000 years of the post-glacial history of the Guinea Coast. Narrow bands of sparse vegetation alternating with broader zones of more luxuriant growth mark, respectively, the lines of former sand barriers and of lagoon deposits.

The Lagos lagoon system is open to the sea by narrow channels and receives the drainage water from some 40,000 square miles of forest country. In the drier months from December to March higher salinities rising from about 10 to 30 per mille prevail, whereas with the coming of the rains the salinity falls sharply to give brackish or fresh conditions which tend to persist with brief intermissions from about April to December. It is against this background of changing salinities that the appearances and disappearances of *Branchiostoma* within the waters and bottom deposits of the lagoon must be viewed.

Laboratory experiments show that the lancelets tolerate changes in temperature greater than those normally encountered within the lagoon but that they die in less than a day's immersion in water of less than 13 per mille salinity. They are, in fact, absent from the lagoon from about mid-May to mid-December, when the salinity is 13 per mille. By mid-December conditions are again favourable for restocking of the lagoon from the persistent populations of lancelets of the outside waters. These latter were found to spawn from about August to October and to give rise to pelagic larvæ ready to seek the bottom and to metamorphose at the earliest some eleven weeks after fertilization, a tally being kept of the length of the larvæ and of the number of their gill pouches at the different ages. Larval life can be extended to twenty weeks or so if a suitable substratum is not available for settlement. Re-population of suitable lagoon deposits can then begin at the moment that the rise in salinity of the lagoon water permits of survival of larvæ drifted in from the sea. Once settlement has been achieved, the lancelets remain in the deposits until killed off in May by the fall in salinity following upon the onset of the March rains. In the meantime, a few of the resident population will have spawned: the young are, however, short-lived, being killed by the influx of fresh water while still in the pelagic phase or shortly after metamorphosis.

The various aspects of these successive events are examined in detail. None is of more interest than the observations and experiments which bear on the substratum requirements of the metamorphosing and adult lancelets. In Nature, animals only occur in coarse sand containing 25 per cent of particles smaller than 0·2 mm. in diameter and in which the finer silts bulk less than 1·5 per cent. While, in laboratory tests, a few animals would settle in soils containing rather more of the fine sand or of the silt, they did not long remain viable. Moreover, it was only in the coarse, open sands that they burrowed normally; in mixtures of progressively finer particles they remained partially buried or rested on the surface. But particle-size is not all. Smooth-grained mixtures are sought after, sharp particles avoided; again, sands with silt or organic matter in excess of a certain amount are not favoured, but neither are those which lack micro-organisms on the surfaces of the grains. It is shown that the particular size-range of particle mixtures chosen by the lancelets are those with a high porosity, that is to say, they have a system of canal spaces within which water may circulate freely.

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[*] *Phil. Trans. Roy. Soc.*, B, **241** (1958). The Ecology of Lagos Lagoon: I, J. E. Webb, The Lagoons of the Guinea Coast, pp. 307–318; II, M. B. Hill and J. E. Webb, The Topography and Physical Conditions of Lagos Harbour and Lagos Lagoon, pp. 319–334; III, J. E. Webb, The Life History of *Branchiostoma nigeriense* Webb, pp. 335–353; IV, M. B. Hill and J. E. Webb, On the Reactions of *Branchiostoma nigeriense* Webb to its Environment, pp. 355–391; V, J. E. Webb, Some Physical Properties of Lagoon Deposits, pp. 393–419.

Thus, in the event, the lancelets select substrata by their texture, but benefit by other properties dependent on texture, such as free drainage.

The community concept, in so far as it applies to animals living in the deposits of the ocean floor, has long been known to be founded upon the selection by animals of soils of varying texture and particle size. Few investigations in recent years have been more revealing of the bases of this selection than those described in the last of the five papers here reviewed.

J. E. SMITH

IMMUNOLOGICAL ASPECTS OF ALLERGIC DISORDERS

"IMMUNOLOGICAL Aspects of Allergic Disorders" was the subject of the symposium of the autumn meeting of the British Society for Immunology, held jointly with the British Association of Allergists, at the Wellcome Building, London, on November 14.

A. W. Frankland introduced the subject as a clinician engaged in the treatment of 'allergic' disorders, for which antigen-antibody reactions are considered responsible. Seasonal pollen asthma, the least complicated allergic disease, responds equally well in 90 per cent of subjects to pre-seasonal treatment with a high dosage of an extract of the pollen of a single grass as with extracts of mixed grass, illustrating the need for studies of pollen antigens. A beneficial effect, however, is also found in between one-third and one-half of the patients treated with saline injections.

The significance of reactions to skin tests showing the presence of reaginic antibodies capable of sensitizing the skin requires clinical confirmation. In 50 per cent of subjects sensitive to pollen skin tests, observed over a period of ten years, clinical sensitivity does not appear to become important. Inhalation tests may confirm the presence of clinical sensitivity.

The clear description of allergic reactions is desirable. Immediate reactions are seen in pollen sensitivity; delayed reactions are of the tuberculin type. An unexplained relationship between these is present in reactions to insect bites. The first bites are usually innocuous, but after a time they may excite reactions of the delayed type. At a later stage, reactions of the immediate type appear, and still later, in some cases, there may be a complete absence of reaction to the bites.

R. Augustin, in a paper entitled "Allergens and other Pollen Antigens", reported her investigations into the relationship of grass pollen antigens, which excite in rabbits the production of precipitating antibodies, and those grass pollen antigens, which are allergenic for man, reacting with the reaginic but non-precipitating antibodies which sensitize the skin, as shown by reactions to skin tests. The complicated pattern of antigen-antibody precipitation lines produced in agar-gel diffusion tests with rabbit antisera were studied for their relevance to allergenic activity in skin tests on man. Enzymic and other studies showed that the antigens of timothy and cocksfoot pollen that were most highly electrically charged were not significantly related to skin-test allergens. The main allergens were found in those antigens having the electrophoretic mobilities and salting out properties of human serum α- and β-globulins. These antigens, on one hand, were precipitated with rabbit antiserum and, on the other, accounted for almost all the allergenic activity in man. The concentrated fractions obtained in this way contained 10–100 million Noon units/mgm. (1 mgm. pollen equals 1,000 Noon units by definition). Coupled preparations of this active allergenic material with red cell stromata and hide powder (Baird and Tatlock) were effective in removing, specifically, the reaginic antibodies from the serum, as shown by passive transfer tests, thus providing a method for demonstrating the presence of reagins.

J. G. Feinberg and H. Grayson discussed the results of "A New Look at the Antibodies to so-called 'Common' Antigens of Grass Pollens". Using antibody gradients and eccentric patterns of precipitation, they showed that rabbit antibodies to pollens have a greater affinity for homospecific than for heterospecific pollens. A similar but greater homospecificity is shown with rabbit antisera to ovalbumin and ovalbumin tagged by means of arsenilic acid. It was suggested that pollen treatment should be based on homospecific pollen allergens.

Some observations on the antibodies related to ragweed pollen were discussed by B. Rose, who with Sehon and his colleagues have found that there are four antibodies in the serum of sensitive patients. Erythrocytes coated with antigen provided a highly sensitive and specific method for demonstrating non-precipitating antibodies. Two of the antibodies found were skin-sensitizing, one was a blocking antibody, and one a hæmagglutinating antibody. The blocking antibody was found in the slow-moving γ_2-globulin and the skin-sensitizing antibody in the fast-moving γ_1-globulin. The skin-sensitizing antibody also moved with the fast-sedimenting $S19$ fraction. The hæmagglutinating antibodies are considered to be similar to the ordinary divalent antibodies and were found in all serum fractions containing skin-sensitizing and/or blocking antibodies.

M. Loveless discussed the reproducibility and practical value of the conjunctival test for estimating the degree of hypersensitivity to ragweed pollen. Reactions to increasing concentrations were observed, and a good correlation was found between the degree of hypersensitivity and the titre of blocking antibody present in the serum after treatment by injection. The conjunctival test was used as a guide to the safe dosage of pollen for injection in a 'repository' form, in emulsion of liquid paraffin and 'Arlacel'. Such a guide is necessary since the dosage of pollen in the limited number of injections of repository required is far higher than the initial doses of aqueous extracts used for conventional methods of pollen treatment.

Investigations into allergic hypersensitivity in man to *Aspergillus fumigatus* were described by J. Pepys, R. W. Riddell, K. M. Citron, Y. M. Clayton and E. I. Short. Allergic reactions to the ubiquitous and perennial spores of *A. fumigatus* consist of rhinitis, conjunctivitis and asthma. The fungus also causes respiratory infections, associated with pulmonary eosinophilia, consisting of transient, recurrent pulmonary infiltrations, febrile episodes and eosinophilia of the sputum and blood. *A. fumigatus* is found with a significantly greater statistical frequency in the sputum of asthmatics without pulmonary eosinophilia than in the sputum of patients with other respiratory disorders.

Hypersensitivity as the cause of the pulmonary eosinophilia was investigated. Skin-prick tests with extracts of *A. fumigatus*, *flavus*, *nidulans*, *niger* and *terreus* gave positive reactions to almost all species in nearly every hypersensitive subject. Culture-medium filtrates, one month old, were the most potent allergens, followed by the cell sap of fresh mycelia, and then by conventional carbol saline extracts of dried mycelium.

Prick tests produced immediate weal-reactions, followed after 3–12 hr. in a number of cases by a 'late' reaction. This reaction was occasionally quite extensive and differed macroscopically and in its more rapid appearance and resolution from the delayed tuberculin type of reaction. Histologically it showed early, intense and persistent infiltration of eosinophile cells, as compared with the perivascular infiltration of round cells in the tuberculin reaction. These features and the demonstration of precipitating antibodies in the serum of patients by means of concentrated extracts of *Aspergillus*, especially *A. fumigatus*, suggest that the 'late' reaction is of the Arthus type.

Bronchial reactions to inhalation tests with extracts of *Aspergillus* were most evident in patients with pulmonary eosinophilia. Proof that the fungus plays a part in the clinical picture must rest, however, not only on evidence of its presence in the sputum, but also on immunological confirmation.

Preliminary investigations into the immunochemistry of *Cladosporium* were reported by J. Longbottom, B. Hayward and R. Augustin. Extracts of spores and mycelium were found to be equal in potency in skin tests. Their active components were found, as with pollen, to be non-dialysable and to be associated with the protein-like material which did not move from the base-line in paper chromatography.

At least eight antigens were demonstrable in agar-gel tests with rabbit antisera to *C. fulvum* and *C. herbarum*. Antiserum to *C. herbarum* gave precipitation lines with the antigens of *C. fulvum*, but not *vice versa*. The *Cladosporium* antigens have the mobilities of serum albumins and α- and β-globulins. Of four antigens shown by immunoelectrophoresis in *C. fulvum*, three were found to be non-allergenic in man. Patients tested with the extracts and with proteolytic digests of the two species showed individual variations, as might be expected.

J. F. Ackroyd discussed a patient with allergic thrombocytopenic purpura due to antazoline. Antazoline added to the serum caused lysis of the platelets and the formation of a precipitate, both mediated by the same antibody. Taking the drug on two later occasions resulted in a rise in the fallen antibody titre. Formation of a precipitate at these times was not, as it had been previously, accompanied by complement fixation; and no cause could be found for this.

The observation that the formation of a precipitate with complement fixation was produced by adding the drug to serum, collected while the patient was taking sufficient antazoline to give high enough blood-levels to excite thrombocytopenia, suggests that the union of the drug and the platelets is very labile. This dissociability may explain why so few persons develop purpura on taking antazoline and other drugs such as sedormid, quinine and quinidine, for which a similar lability has been observed.

J. PEPYS

THE NEW FERODO RESEARCH LABORATORIES

By DR. R. C. PARKER

Research Director

ON November 21, some sixty-one years after Mr. Herbert Frood, the founder of Ferodo Ltd., produced his first friction material, H.R.H. the Duke of Edinburgh formally opened the new Research Laboratories of the firm by unveiling a suitably inscribed bronze plaque. Work on current problems was afterwards inspected. In the following week a series of open days were arranged, one of which was reserved for the teaching staffs of universities, local technical colleges and schools and for the staffs of research institutes.

The building (Fig. 1) is in the form of a splayed *E* having a total floor area of 75,000 sq. ft. The upper two stories of the front of the building house the Administration Department, a Plant Development Department and offices for senior managers, while the two-storied centre wing with a floor area of 12,000 sq. ft. houses the Physical, Chemical and Metallurgical Laboratories. All the internal partitions in both laboratories and offices are built on a five-foot module and can be readily mounted or removed as desired. The left-hand wing, covering 21,000 sq. ft., comprises an Engineering Test House, a workshop and a test car garage, and the right-hand wing, with an area of 18,000 sq. ft., contains pilot plant. The site of the building is such that when further space is required the length of the three projecting wings can be increased by 50 per cent. The building is pleasantly situated on the main road from Chapel-en-le-Frith to Hayfield, and is set among landscape gardens.

The main heating of the offices and the laboratories is by warm water that circulates through special steel coils embedded in the ceilings. Supplementing

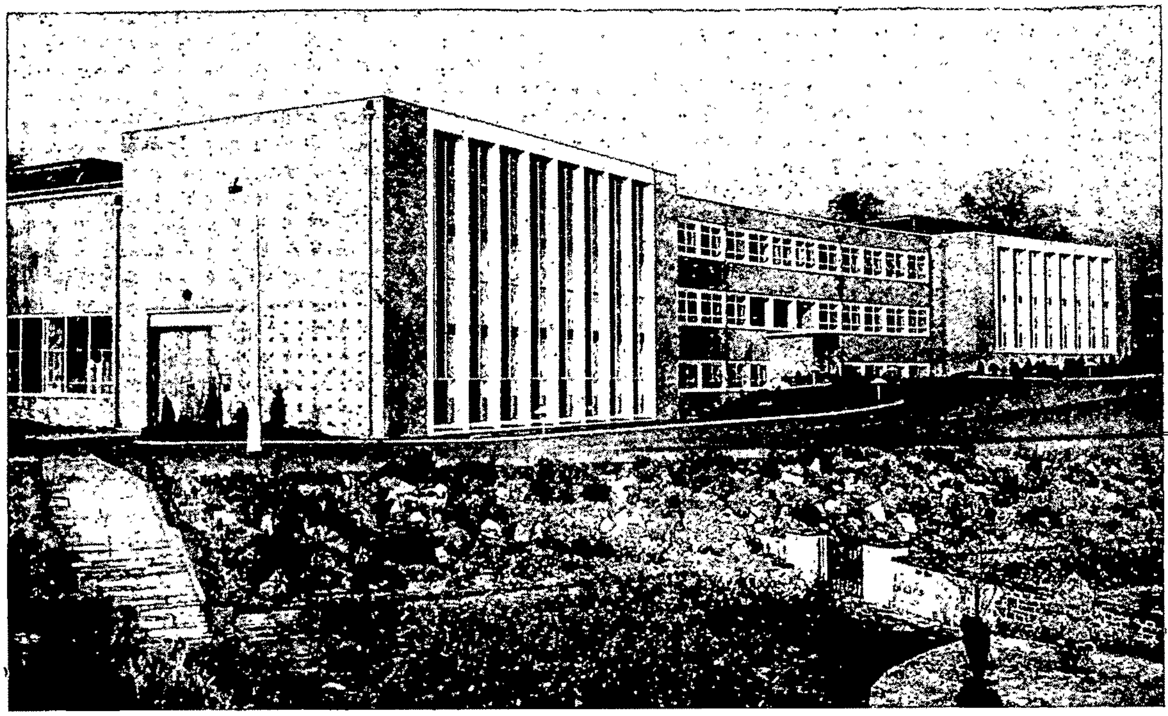

Fig. 1. The new Ferodo Research Laboratories at Chapel-en-le-Frith

this is warm filtered air which is led into each five-foot module, and afterwards extraction is by a fan system so designed that the air in each room is changed from four to five times every hour. The two outer wings are heated by unit heaters of the down-stream type fixed high in the roof and controlled by thermostats fixed at working level. Ventilation of these outer wings is by means of fresh-air ducts connected to the unit heaters and by extraction fans in the roof. In addition to gas, hot and cold water is provided, together with the usual electrical services. Steam is provided at 180 lb./sq. in. and at 40 lb./sq. in., and compressed air at 100 lb./sq. in. All services to the laboratories are housed in timber ducts that run along the walls from window-sill-level to floor-level. Services to island benches are accommodated beneath the timber and reinforced concrete floor.

The laboratories are lit by 80-watt fluorescent tubes in fittings on the ceilings, giving an average value of illumination of about 30 lumens per sq. ft. at desk-level. The Test House and Experimental Production Laboratory are lit by 250-watt mercury vapour lamps and 500-watt tungsten filament lamps which give an illumination of some 18 lumens per sq. ft.

The research and development programmes carried out in the new building are all directed towards the production of improved types of friction material for the automotive industry and for railways, aviation, mining and indeed every industry that employs moving machinery. Almost irrespective of the application, demands on friction materials are ever increasing both in number and intensity, and in the case of automotive brakes, for example, the peak energy dissipation per unit area has more than doubled within the past decade. Attention has not only to be given to the level of friction under varying conditions of pressure, speed, temperature and surface roughness, but also to durability, squeal, oil resistance, water resistance and many other such factors.

In order to be able to produce durable material with the required value of friction, research in the laboratories is carried out along many inter-related channels. Long-term work is carried out on the mechanism of friction and wear, and this involves the study of the bulk and surface properties of a wide range of different materials. Next, basic work of a medium-term nature follows on the friction materials themselves, and this has, as one of its objects, the further study of certain aspects of behaviour to which the long-term programme has directed attention. The third, last and most important link in the chain is the development of new friction materials to solve immediate problems, a process which, though continually eased by the ~~flow of knowledge~~ from the longer-term programmes, nevertheless ~~derives a~~ great deal from intuition and past experience. In parallel with this work on friction and wear, detailed researches are carried out on the properties of the more important raw materials. Asbestos is a particularly important material since, being a fibrous inorganic mineral, it is associated with three essential properties, namely, heat resistance, strength and flexibility. Studies on this mineral are being carried out by means of X-ray diffraction, electron microscopy and other techniques, and the structure of chrysotile and one of the amphiboles, namely, Bolivian crocidolite, has been elucidated. The investigations are run parallel with work on other properties of asbestos in order to obtain the clearest understanding of its many important characteristics. Investigations are also made of natural oils and resins by means of infra-red spectroscopy and liquid and gas chromatography, not only with the object of seeking a correlation between their properties and the friction and wear of the final product, but also to ensure that when complex mixes are involved, the components can be identified so that the activity of the oils can be maintained constant by a suitable system of blending. Mechanical investigations are used to examine the behaviour of the many different types of brakes and to record the conditions to which they are subjected in service. Surface temperature is one of the many important variables, and both its measurement and calculation are of vital importance.

The Test House contains test dynamometers of the inertia type for examining experimental materials under conditions that can be encountered in service. The machines are, in the main, automatic in operation and are self-recording, and permit a much closer control and therefore a better opportunity for studying the various factors affecting behaviour. The larger machines are designed to fit the types of brakes used on aircraft, heavy transport, railways and industrial brakes, while on the smaller machines provision is made to fit brakes varying from automotive to bicycle. The workshop adjoining the Test House is fully equipped to make all but the large parts of the various test machines, and the laboratories situated on a second floor over the workshop and test car garage are concerned with the design and construction of the various servo and other devices needed for the operation and control of the machines. Towards the end of the wing is a test car garage which houses a fleet of test vehicles, including motorcycles, large and small saloon cars, high-performance sports cars, lorries and buses. The vehicles are all fitted with instruments of various types which, in effect, make them mobile laboratories.

Although the laboratories stand adjacent to the factory, it was considered essential for them to be self-contained, and to this end the pilot-plant laboratory is equipped with all the production plant and finishing apparatus required to make prototype materials. Such provision not only enables development staff to plan their work more easily, but also frees production plant in the factory from costly interruptions. One section of this wing is allocated to the Production Plant Development Section, which carries out all the proving trials that may be necessary on new plant of a novel design. This design section works not only in close co-operation with the pilot plant section, but also with those chemists and physicists who are concerned with ideas still only in their embryonic stage.

Even this brief description of the laboratories should serve to show that the study of friction and the manufacture of friction materials involves contributions from chemists, engineers, metallurgists, mathematicians, statisticians, physicists and physical chemists. Indeed, the added interest gained from co-operating with so many different disciplines serves to render a fascinating study exhilarating.

The architects for the new Ferodo Research Laboratories were Messrs. Ashworth and Fletcher; the quantity surveyors Messrs. Worrell and Kelly; and the consulting engineers Messrs. R. W. Gregory and Partners.

THE SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING

THE annual meeting of the Science Masters' Association was held in University College and Queen Elizabeth College, London, during December 30–January 2, and was attended by a thousand members and many guests; this number included members from Canada, India, Pakistan, South and West Africa, and the United States. Among them was Prof. R. W. Lefler, of Purdue University, Indiana, who is at present acting as adviser in physics to the Nationalist University in Formosa.

The meeting began with the presidential address by Sir Lawrence Bragg, who outlined the past history and present policy of the Royal Institution. The second evening was occupied by a lecture by Dr. H. Lister on the recent Trans-Antarctic Expedition; this was notable for the splendid coloured slides.

The programme of morning lectures by members of the staff of University College, together with guest lecturers from Harwell, the Brunel College of Technology, the London Institute of Education, and Woodberry Down School, London, has already been given in *Nature* (December 6, p. 1554). One of these, that by Mr. H. G. Conway, of Short Brothers and Harland, Belfast, on "New Engineering Problems in Aeronautics", was attended by Air Marshal Sir Owen Jones, president of the Institution of Mechanical Engineers, and other members of the Institution.

The Manufacturers' and Publishers' Exhibitions, held in University College, were larger than ever before, with the result that the exhibition of apparatus and other items brought by members had to be housed in Queen Elizabeth College. Among these exhibits was an intensely interesting historic one, namely, Faraday's bible, shown by Mr. E. H. Duckworth, of Cheltenham; this contained Faraday's autograph and his original marking of important texts.

The Science and Religion Group was addressed by the Rev. Aubrey Vine, general secretary of the Free Church Federal Council.

An innovation was the organization, at the suggestion of Mr. D. G. Chisman, education officer of the Royal Institute of Chemistry, of evening receptions by that Institute and by the Institutes of Physics and of Biology. These were much appreciated by members, as was shown by the fact that applications to attend far exceeded the available accommodation. The afternoons were occupied by visits to university departments and to factories in or near London; for other members there were exhibitions of scientific films.

At the business meeting of the Association Mr. D. G. James, vice-chancellor of the University of Southampton, was elected president for the ensuing year: Dr. H. F. Boulind, of the University of Cambridge Department of Education, was elected chairman, and Mr. H. Lockett, of Taunton's School, Southampton, became the new annual meeting secretary. It was announced that a summer meeting would be held, during July 28–31, in the Durham Colleges of the University of Durham. The next annual meeting will be in the University of Southampton, during December 29–January 1, 1960.

The second half of the business meeting was occupied with the discussion of a resolution, moved by Mr. D. N. Underwood and Mr. E. Chanter, which read: "that this meeting disapproves of the continued teaching of General Science as a substitute for the separate sciences". The chairman, Mr. Charles Holt, said that it was somewhat unusual for resolutions of this kind to be brought forward at the business meeting, but that the General Committee had decided that a useful purpose would be served if it were discussed. The Committee had always tried to avoid "coming down heavily on any particular side in science, because it took the view that members were so differently situated that they might find they had different needs at different stages of the work".

Mr. Underwood said the decision to move the resolution had been taken during the annual meeting last year at Leeds; concern on the subject had also been shown in articles in the *School Science Review* and in many letters and comments which the proposers had received in favour of the resolution. They were concerned chiefly with the effect of the teaching of general science on potential scientists, and not so much with that on the weaker grammar school and modern school pupil. It was a fallacy to think that physics, chemistry, and biology could be lumped together as general science; they were different disciplines and should be taught by experts. General science meant reduced time for science and provided little opportunity for practical work.

Mr. Chanter, in seconding the motion, said that in general science "one had to go quickly from one thing to another and the pupil never really got his teeth into anything". He did not believe that was real education at all.

The discussion was opened by a member who said that the sciences were humanities, and that the most human things about them were the barriers between them; the thing about chemistry which made it not physics was one of the most charming things.

Mr. J. A. Storer suggested an amendment, which was supported by Mr. D. Lewis (Bristol). This was later withdrawn after Mr. R. H. Dyball (City of London School) had proposed the altered wording "that this meeting disapproves of the continued teaching of general science on an inadequate time allowance". Mr. H. P. Ramage (Gresham's School, Holt) supported Mr. Dyball, and said that if physics, chemistry, and biology, with some geology and astronomy, were studied separately, it was still general science in the Association's meaning of the term. He would like to see enough time given to teach all these subjects up to Advanced (*A*) level; but the original resolution, if carried, would be misquoted and give a very wrong impression. After further discussion, the amendment proposed by Mr. Dyball was carried by an overwhelming majority.

The second discussion was on the Association's policy statement, "Science and Education", which has been widely distributed in educational circles. This was introduced by the chairman-elect, Dr. H. F. Boulind, who said that the main reason for the statement was "dissatisfaction with the present state of science teaching; the country is not producing the scientists, technicians, and technologists required". Secondly, it is science which is shaping the modern world, and some reasonable standard of scientific understanding is essential for everyone. The statement was produced by a sub-committee of two physicists, two chemists, and two biologists, and had been almost unanimously approved by the General Committee. It had been discussed with the Minister of Education and with Under-Secretaries, with the Central Advisory Committee, and with the Secondary School Examinations Committee; later work had been undertaken by specialist panels. Among the recommendations were the following: "that all pupils should follow an adequate course in science up to the end of the fifth-form year"; that "science should be studied by all pupils in the sixth form", and that "subject specialization should be retained in the sixth form but that *A* level syllabuses should be reduced in factual content".

In the discussion, a member said the problem should be considered from the point of view of the non-scientist; many important subjects are left out at Ordinary (*O*) level, so that pupils leaving at the age of 16 never touch them. Several members commented that the examining boards are favourable to a reduction in the factual content of examinations. Mr. W. H. Dovell (Lancing) thought that there are too many topics of interest only to the specialist in the *O* level course. He also asked for Dr. Boulind's views on the number of teaching periods a week. Dr. Boulind, in reply, said that nine periods a week should be adequate up to *O* level. Many members dissented at once. Mr. G. A. Lees (Collyer's School, Horsham) said that the policy statement was a very good effort, but that practical details as to time allowances were much more important. Further discussion centred on the question whether junior school science teaching should all be in the hands of one teacher or in those of specialists; on the influence which the Association might exert in introducing science into the common entrance examination for public schools; and on the effect of the statement on science teaching in modern schools and comprehensive schools. The chairman, in closing the discussion, mentioned that Dr. Boulind had been mainly responsible for the policy statement.

MANAGEMENT THEORY

THE third booklet in the "Problems of Progress in Industry" issued by the Department of Industrial and Scientific Research (Management and Technology. By Joan Woodward. Pp. 40. London: H.M. Stationery Office, 1958. 2*s*. 6*d*. net) describes a survey of the management organization of a hundred firms in south Essex. The survey attempted to discover whether the principles of organization laid down by an expanding body of management theory correlate with business success when put into practice. The survey was made between 1953 and 1957 by the Human Relations Research Unit of the South-East Essex Technical College, and after a basic survey of 91 per cent of manufacturing firms in south Essex with more than a hundred employees, twenty firms were studied more fully and detailed case-studies made of three firms in which production systems were mixed or changing. A full report of the research with a discussion of its theoretical implications is projected shortly under the title "Management

Organization: Theory and Practice". Among the large-batch and mass-production firms a relation was observed between conformity with the 'rules' of management and business success, and, within this limited range of production systems, observance of these 'rules' appears to increase administrative efficiency. Elsewhere, however, it appears that new 'rules' are needed and an alternative kind of organizational structure might be more appropriate. This does not invalidate management theory, which contains important and valuable information and ideas, but its limitations must be recognized and its principles subjected to critical analysis. Broadly, the survey brings out the way in which management organization varies according to the technical demands of the manufacturing process. The character of the basic functions of management, their chronological sequence, their integration and their relative importance to the success and survival of the business, all depend on the system of techniques in the particular firm, and they differ mainly between unit, mass and process production, all of which have different priorities.

Accordingly, a 'cause and effect' relation can be traced between a system of production and its organizational pattern, and, as a result, the probable organizational requirements predicted. The booklet emphasizes the danger in the tendency to teach the principles of administration as if they were scientific laws, when they are really little more than administrative expedients. Management studies can, so far, identify symptoms and remedies, but many more descriptive accounts, like that given in this booklet, of the circumstances in which different administrative expedients have proved successful are required to supplant traditional teaching. It is also concluded that technical changes not associated with changes in either objectives or the production system are unlikely to create much disturbance in the organizational pattern. Where, however, such changes are likely to create new 'situational demands', these could be foreseen by a systematic analysis of the new technology.

HUMAN RELATIONS IN INDUSTRY

IN its final report*, the Joint Committee on Human Relations in Industry, 1954–57, reviewing research projects approved since its first report, records that a practical inquiry into the effects of work study on human relations and organization at every level in the firm is well advanced, and further support was recommended for a team from the University of Manchester to continue to work on a large scale for three years on social factors affecting norms of production in British factories. An investigation into incentives for management had to be abandoned because suitable staff could not be found, but the National Institute of Industrial Psychology has been asked to undertake case-studies of the way in which individual firms have tackled the problem of foremanship.

Research in the field of industrial communication has been extended to cover the communication of technical information to firms from outside sources, and the inquiry conducted by the Oxford Institute of Statistics into factors affecting productivity has been extended to social factors in seeking for an explanation—psychological and social, as well as economic—of differences in productivity between and within the firms studied. Research into the community aspects of technological change in South Wales has centred around the exceptionally modern and highly mechanized Margam steel plant and, at Cardiff, on the impact made on the structure and procedure of the trades unions by the new steel plant.

The Acton Society Trust is making a case-study of the introduction of a management-development programme, and a study of educational provision and the needs of industry by the Tavistock Institute of Human Relations is also being supported. Work at the London School of Economics on the employment of women in industry was extended for two years, and some exploratory work was undertaken at the University of Edinburgh into the employment of older workers in industry.

Projects sponsored by the Joint Committee on Individual Efficiency in Industry fall into four groups. Those concerned with factors affecting equipment design and working conditions include two studies, by the Medical Research Council's Applied Psychology Research Unit at Cambridge, of manual controls of machine tools and of visual fatigue. The former greatly increased the speed of machine-working and reduced the number of errors and learning-time. Other studies were concerned with the design and layout of control points in steelworks, with special reference to crane-cabs, with machine controls in relation to equipment used in the boot and shoe industry and with the response to work in high temperatures in relation to age. Projects concerned with industrial engineering techniques embrace those of the nature and acquisition of industrial skills by the Department of Engineering Production at the University of Birmingham and of work-study rating, rest and fatigue allowances by the Department of Aircraft Economics at the College of Aeronautics, Cranfield.

Studies of problems of training include those by the National Institute of Industrial Psychology of methods of training in industrial skills; of conditions influencing the rate of learning of paced and unpaced motor tasks by the University of Oxford Institute of Experimental Psychology; of the methods used by the best operatives and their application to the training and re-training of operatives by the British Boot, Shoe and Allied Trades Research Association; and of reading efficiency by the Department of Commerce and Professional Studies at the North-Western Polytechnic, London.

Among the group of miscellaneous projects may be mentioned one on the effect of knowledge of results on production made by the Medical Research Council's Applied Psychology Research Unit; an investigation of indices commonly regarded as indicating the adjustment of the individual to his job; and a study of automation in relation to skill and the design of machines by the Department of Psychology, University of Cambridge.

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* Department of Scientific and Industrial Research. Final Report of the Joint Committee on Human Relations in Industry 1954–57 and Report of the Joint Committee on Individual Efficiency in Industry 1953–57. Pp. vi+44. (London: H.M. Stationery Office, 1958.) 3*s*. net.

A CASE OF HUMAN INTERSEXUALITY HAVING A POSSIBLE XXY SEX-DETERMINING MECHANISM

By PATRICIA A. JACOBS and DR. J. A. STRONG

Medical Research Council Group for Research on the General Effects of Radiation and Department for Endocrine and Metabolic Diseases, Western General Hospital and University of Edinburgh

RECENT improvements in techniques for the examination of human somatic chromosomes have made possible the study of the chromosome complement of human intersexes; consequently, it is now practicable to investigate the relationship in these cases between sex as determined by direct chromosome study, and sex as inferred from the study of 'nuclear sex chromatin' of the type described by Barr and Bertram[1]. This report is concerned with one of a series of patients with gonadal dysgenesis who are under investigation, and the particular feature of interest is the occurrence of 47 somatic chromosomes in contrast with the normal number of 46 in man.

In recent years the diploid chromosome number of 46 has been recorded in a large number of instances. In addition to the 60 cases cited in a previous publication[2] we have recorded a diploid number of 46 in bone marrow preparations from a further 40 European subjects. Kodani, on the other hand, has recently published results of counts made on testicular material from 36 Japanese and 8 American white males[3,4]. He claims that in 16 Japanese and 1 American there was a diploid number of 48; in 2 Japanese a diploid number of 47, and that in the remaining 13 Japanese and 7 whites the number was 46. He suggests that 46 is the basic diploid chromosome number for man, but in some instances there are additional "supernumerary chromosomes". The occurrence of this type of supernumerary chromosome, however, has not been reported previously among the vertebrates and awaits confirmation by other workers.

Our patient, an apparent male aged twenty-four, was presented as a case of gonadal dysgenesis with gynæcomastia and small testes associated with poor facial hair-growth and a high-pitched voice. Biopsy examination of testicular tissue showed the seminiferous tubules to be extremely hyalinized and atrophic, and also an apparent increase in the number of interstitial cells. Chromosome studies were attempted on part of this material, but no spermatogonial mitotic or meiotic divisions were seen. Smears made from both the buccal mucosa and the blood were examined by Dr. B. Lennox of the Department of Pathology, Western Infirmary, Glasgow, and found to demonstrate typical female morphology with regard to their nuclear sex chromatin.

Material obtained by sternal marrow puncture was used for investigating the somatic chromosomes. The technique used for culturing the material in the presence of colchicine and for making squash preparations has already been described[2].

The chromosomes were counted in 44 cells in metaphase and the results are shown in Table 1.

The majority of the cells contained 47 chromosomes, and in all those cells where the chromosomes were well fixed and spread, the count was undoubtedly 47 (Fig. 1). The apparent variation is in all probability due to technical errors. Fragments of cells containing chromosomes may become lost during the squashing process so that counts lower than the diploid number are obtained; and occasionally chromosomes split at the centromere and individual chromatids may be counted as chromosomes, giving a count higher than the diploid number[2].

Table 1

Chromosome No.	45	46	47	48	49
No. of cells	2	7	29	5	1

A study of the chromosome morphology in 8 cells of a suitably high standard showed that each of these had a normal male complement with the Y chromosome present, but that there was also an extra chromosome having a sub-median centromere occurring in the medium size range. In the normal male there are 15 chromosomes in this range, and in the female 16, all having sub-terminal or sub-median centromeres[2]. Owing to the slight variations in their size and morphology these chromosomes have proved difficult to pair, and it is in this category that the X chromosome is to be found.

There are strong grounds, both observational and genetic[5,6], for believing that human beings with chromatin-positive nuclei are genetic females having two X chromosomes. The fact that this patient is chromatin-positive and has an additional chromosome within the same size range as the X, as well as an apparently normal Y, makes it seem likely that he has the genetic constitution XXY. The possibility cannot be excluded, however, that the additional chromosome is an autosome carrying feminizing genes.

The presence of the extra chromosome might have been due to one or other of the parents having 47 chromosomes, and, therefore, chromosome studies were made on marrow specimens from both parents. Both were found to have a diploid number of 46 (Table 2), and analysis of cells of suitable quality showed the morphology of the chromosomes to be normal.

The occurrence of the extra chromosome therefore may be due to non-disjunction at either mitosis or meiosis during gametogenesis in one or other parent. Alternatively, it may be due to non-disjunction

Fig. 1. Metaphase plate showing 47 chromosomes

Table 2

Father	Chromosome No.	44	45	46	47	48	49
32 cells counted	No. of cells	2	3	26	–	–	1
Mother	Chromosome No.	44	45	46	47	48	49
39 cells counted	No. of cells	1	3	33	2	—	–

occurring during the patient's very early embryological development, in which case there is a possibility that the patient may be a mosaic. Unfortunately, it is not possible with the techniques at present available to examine the chromosomes of tissues arising from different germ layers of the embryo.

We would like to thank Dr. B. Lennox of the Department of Pathology, Western Infirmary, Glasgow, for checking the nuclear sex of the preparations of buccal mucosa and blood and Miss M. Brunton for technical assistance.

A further report of this and other cases will follow.

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DISTRIBUTION OF NEWLY SYNTHESIZED DEOXYRIBONUCLEIC ACID IN DIVIDING CHROMOSOMES

By PHILIP S. WOODS and MARIE U. SCHAIRER
Biology Department, Brookhaven National Laboratory, Upton, Long Island, New York

FROM autoradiographic studies with tritiated thymidine, newly synthesized deoxyribonucleic acid was shown to be equally distributed between both daughter chromosomes at anaphase by Taylor, Woods and Hughes[1] (Fig. 1*A* and *B*). When the labelled chromosomes were allowed to duplicate a second time in a medium containing no radioactive tracer, the isotope appeared in only one daughter chromosome of each sister pair (Fig. 1*C*). These findings differed markedly from the earlier conclusions of Plaut and Mazia[2], whose interpretations were based on the analysis of deoxyribonucleic acid labelled with carbon-14 in whole sets of daughter chromosomes in anaphase and telophase. Since they observed significant differences in the amount of label between the two daughter nuclei, they concluded that individual chromosomes were also labelled unequally. Recently, La Cour and Pelc[3] reported that unequal labelling could occur as a result of treatment with colchicine. Since in the experiment of Taylor *et al.* colchicine was present during the second synthesis and absent during the first, they suggested that colchicine may produce the unequal label.

In order to clarify the situation, the experiments of La Cour and Pelc were repeated. Since critical quantitative data were lacking in their experiments, information in the form of grain counts over a number of daughter chromosome pairs were collected and the chi-square test applied to determine any significant deviations between daughter halves.

The experiment went as follows: two seedlings of *Vicia faba* were grown in separate nutrient solutions containing tritiated thymidine (1·4 μgm./ml., 2·0 μc./ml.). One solution contained in addition 0·03 per cent colchicine. After 8 hr. the seedling which was treated with thymidine labelled with tritium alone was removed and placed in a non-labelled solution containing 0·03 per cent colchicine. After 6 additional hours two roots of this seedling were fixed, stained by the Feulgen squash procedure, and covered with autoradiographic stripping film. The other

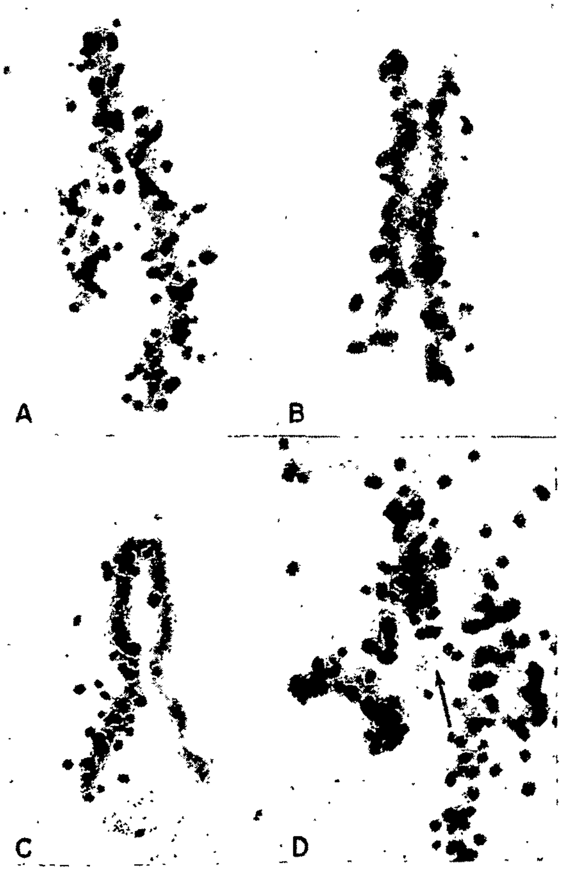

Fig. 1. *A*, autoradiograph of chromosome number 9 of second root of Table 2, colchicine present during synthesis; *B*, autoradiograph of chromosome number 4 of second root of Table 1, colchicine absent during synthesis; *C*, autoradiograph of chromosome from root treated with tritiated thymidine for 8 hr. followed by colchicine solution without tritiated thymidine for 30 hr.; *D*, autoradiograph of chromosomes from lightly squashed root from same seedling as that used in *B*

seedling was grown for a total of 12 hr. in the labelled thymidine–colchicine solution, and then two roots were fixed and processed identically with those of the first seedling. Definite criteria were followed for obtaining the grain counts. Since Fitzgerald *et al.*[4] have shown that 90 per cent of the beta-particles emitted by tritium are absorbed by filters (corrected to unit density) with a thickness of only 1·2μ, labelled material would not be expected to register fully unless in direct contact with the photographic emulsion. Therefore, we have scored only those chromosomes that were seen by the phase-contrast microscope to be in direct contact with the emulsion. All other chromosomes such as those with varying thicknesses of cytoplasm or cell wall lying above were rejected. The first 25 chromosomes encountered where the criteria were fulfilled were counted for each of the four roots. Thus, 50 chromosomes were scored from each of two roots where colchicine was either present or absent during the period of synthesis of deoxyribonucleic acid.

Tables 1 and 2 show the results of these experiments. The fourth column of each table shows the mean or expected count for the left and right chromatid of each chromosome if equal labelling were to occur. The last column of each table shows the values of chi-square for each chromatid pair. It is clear from the high probability values that the observed grain count values do not differ significantly from the expected values of the 1 : 1 hypothesis. Apparently each daughter chromosome of a pair contains the same amount of new deoxyribonucleic acid. Also, there appears to be no difference between the two treatments. The presence or absence of colchicine during synthesis has no effect on the distribution of the labelled material. Fig. 1*A* and *B* illustrates two chromosomes that were counted for each treatment.

Table 1. GRAIN COUNTS OF FIFTY CHROMOSOMES FROM TWO *Vicia faba* ROOTS TREATED WITH TRITIATED THYMIDINE FOR 8 HR. FOLLOWED BY NON-LABELLED COLCHICINE SOLUTION FOR 6 HR.

Chromosome number	Grain counts for left chromatid	Grain counts for right chromatid	Mean or expected count for left and right chromatid	Chi-square
1	20	17	18·5	0·24
2	7	6	6·5	0·07
3	20	13	16·5	1·48
4	18	17	17·5	0·03
5	33	38	35·5	0·35
6	9	13	11·0	0·72
7	17	23	20·0	0·90
8	17	27	22·0	2·27
9	6	10	8·0	1·00
10	7	8	7·5	0·07
11	18	13	15·5	0·80
12	13	12	12·5	0·04
13	11	12	11·5	0·04
14	48	30	39·0	4·15*
15	18	13	15·5	0·80
16	9	6	7·5	0·60
17	30	29	29·5	0·02
18	15	6	10·5	3·85*
19	8	10	9·0	0·22
20	15	14	14·5	0·03
21	27	26	26·5	0·02
22	14	20	17·0	1·05
23	17	13	15·0	0·53
24	12	11	11·5	0·04
25	3	9	6·0	3·00
1	12	19	15·5	1·58
2	21	21	21·0	0
3	7	11	9·0	0·88
4	21	27	24·0	0·75
5	4	9	6·5	1·92
6	12	16	14·0	0·57
7	11	10	10·5	0·05
8	11	13	12·0	0·17
9	21	23	22·0	0·09
10	8	4	6·0	1·33
11	12	13	12·5	0·04
12	10	4	7·0	2·57
13	16	27	21·5	2·81
14	22	16	19·0	0·95
15	17	17	17·0	0
16	8	8	8·0	0
17	16	21	18·5	0·68
18	26	17	21·5	1·88
19	8	14	11·0	1·63
20	16	15	15·5	0·03
21	17	19	18·0	0·11
22	10	15	12·5	1·00
23	30	20	25·0	2·00
24	4	5	4·5	0·11
25	4	3	3·5	0·14
			χ^2 (50 d.f.) =	43·61
			P =	0·72

* Significant at 5 per cent level

Table 2. GRAIN COUNTS OF FIFTY CHROMOSOMES FROM TWO *Vicia faba* ROOTS TREATED SIMULTANEOUSLY WITH TRITIATED THYMIDINE AND COLCHICINE FOR 12 HR.

Chromosome number	Grain counts for left chromatid	Grain counts for right chromatid	Mean or expected count for left and right chromatid	Chi-square
1	5	6	5·5	0·09
2	8	9	8·5	0·06
3	3	3	3·0	0
4	5	4	4·5	0·11
5	13	8	10·5	1·19
6	9	5	7·0	1·14
7	7	6	6·5	0·08
8	7	5	6·0	0·33
9	8	7	7·5	0·07
10	7	10	8·5	0·53
11	32	30	31·0	0·06
12	12	7	9·5	1·32
13	9	20	14·5	4·17*
14	15	13	14·0	0·14
15	14	12	13·0	0·15
16	11	12	11·5	0·04
17	19	29	24·0	2·08
18	13	14	13·5	0·04
19	33	25	29·0	1·10
20	8	9	8·5	0·06
21	20	25	22·5	0·56
22	12	16	14·0	0·57
23	13	8	10·5	1·19
24	13	9	11·0	0·73
25	20	25	27·5	0·56
1	15	19	17·0	0·47
2	14	17	15·5	0·29
3	27	23	25·0	0·32
4	7	9	8·0	0·25
5	10	16	13·0	1·38
6	5	8	6·5	0·69
7	7	6	6·5	0·08
8	9	8	8·5	0·06
9	30	32	31·0	0·06
10	10	18	14·0	2·28
11	20	25	22·5	0·56
12	12	13	12·5	0·04
13	22	19	20·5	0·22
14	7	10	8·5	0·53
15	16	11	13·5	0·93
16	19	10	14·5	2·79
17	10	11	10·5	0·05
18	6	11	8·5	1·47
19	25	15	20·0	2·50
20	14	16	15·0	0·13
21	10	9	9·5	0·05
22	15	10	12·5	1·00
23	23	21	22·0	0·09
24	20	18	19·0	0·11
25	4	10	7·0	2·57
			χ^2 (50 d.f.) =	35·29
			P =	0·94

* Significant at 5 per cent level

Explanation of the findings of La Cour and Pelc[3] in the light of the present results should be considered. In our opinion, differential absorbance of tritium beta-particles by varying thicknesses of cytoplasm and other cellular components has not been sufficiently considered by these workers. It is probable that a chromosome labelled with tritium would not produce a satisfactory autoradiograph if it were separated from the emulsion during exposure by a layer of dry cytoplasm only a few microns thick.

It is clear that unless the chromosomes are heavily squashed so that the thickness of the absorbing layer is reduced to a minimum or is at least constant, inconsistent results would be expected. Fig. 1*D* shows a preparation in which one chromosome (arrow) of a group was farther from the emulsion than the others and in which the absorbing layer was thicker.

This investigation was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

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SEPARATION AND ANALYSIS OF SCALE-RICH MATERIAL FROM WOOL

By Dr. J. H. BRADBURY

Wool Textile Research Laboratories, Commonwealth Scientific and
Industrial Research Organization, Geelong,
Australia

THE scales of animal fibres can be removed by physical methods such as abrasion[1-3], by enzymic methods[4], and by chemical methods[5-8]. The disadvantage of the chemical and enzymic methods is that it is impossible to estimate the degree of degradation of the scales which has occurred during the treatment. The abrasion technique has not been used for producing scales for analysis but rather to obtain descaled fibres for analysis[2] and dyeing experiments[3]. In this communication an abrasion technique is used to produce 0·5-mgm. amounts of scale-rich material which are quantitatively analysed for amino-acids by Levy's method[9].

The glass descaler is shown in Fig. 1. The central rod *A* comes to a chisel edge at *B*, which is fire-polished and has a cut made across it with a sharp glass-knife. This serves as an abrasive groove for the wool fibre *C*, which is held by tweezers and threaded through the holes *D* at either end of the descaler. When the fibre is rubbed once back and forth along the groove small particles are abraded and collect on the sides of the descaler. To ascertain the depth of abrasion of Lincoln 36's and Corriedale 46's fibres they were ring-dyed with 0·01 per cent Cibalan Bordeaux 3*BL* in 0·1 per cent glacial acetic acid at 80° C. for 1 hr., cross-sectioned with a Hardy microtome and the average depth of dyeing measured over 100 cross-sections. This amounted to 3·1 and 2·9 per cent of the diameter for Lincoln 36's and Corriedale 46's, respectively. Before use, each descaler was tested with the appropriate ring-dyed fibres and the scale material examined under the microscope. In every case it consisted of small, coloured pieces, showing that it originated from the outside layers of the fibre. A further check was made by calculating the average dimensions of the material abraded, from a knowledge of the percentage by weight removed from one side of the fibre, which is assumed to be circular in cross-section. When 0·50 per cent by weight of the fibre is abraded the calculated average depth of abrasion at the deepest point amounts to 2·0 per cent of the diameter. Since the thickness of the scales as determined by microscopy[10] is about 1·7 per cent of the diameter, the abraded material is very largely, but not entirely, scales.

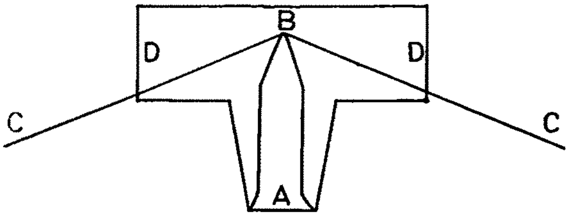

Fig. 1. Glass descaler, distance $DD \simeq 3$ cm., $AB \simeq 2$ cm.

After such preliminary testing each descaler was carefully cleaned, dried and allowed to come to constant weight at 65 per cent relative humidity and 20° C. After about 0·5 mgm. of scale material had collected from the abrasion of 200–400 fibres (cleaned as described previously[11]) the descaler was again weighed to constant weight ($\pm 5 \times 10^{-3}$ mgm.) and placed inside a large, carefully cleaned 'Pyrex' test-tube. Twice glass-distilled 6 *M* hydrochloric acid (2 ml.) was added, the tube sealed under vacuum and heated at 105° C. for 16 hr. The hydrolysate was dinitrophenylated by Sanger's method[12] and the dinitrophenyl-amino-acids separated and estimated by a modification of the method of Levy[9] which will be described elsewhere. Similar quadruplicate analyses of whole fibres were made for the three different samples of wool recorded in Table 1.

It is clear that the scales are rich in proline and poor in aspartic acid and glutamic acid in all three wools examined. However, substantial differences

Table 1. Percentage Deviations of Amino-acid Content of Scale-rich Material from that of Whole Fibre which are significant at the 1 per cent Probability Level unless otherwise stated

Amino-acid	Lincoln 36's (virgin wool, tips removed)	Lincoln 36's (obtained in top form)	Corriedale 46's (virgin wool, tips removed)
Asp Glu	− 27·5*	− 14·2† − 13·0	− 24·1 − 22·7*
Pro	+ 33·0	+ 20·6	+ 27·3*
Cys	—	+ 21·8	—
Gly	+ 38·7	—	—

* Significant at the 5 per cent probability level.

† $P = 0{\cdot}068$ in this case due to poor separation of DNP-Asp from DNP-Glu in some of the experiments.

between types may be expected since the scales are rich in glycine in Lincoln 36's virgin wool and rich in cystine in Lincoln 36's top. Scale material produced by various degradative chemical methods is reported to contain more cystine and less tyrosine than the whole fibre[5-8]. The differences between such results and those given here are due to the different methods of separating the scale material and possible variations in composition between various samples of wool and between the three histological components of the scales[13].

It is perhaps significant that the scales which are known to be amorphous[5,14,15] have a higher proline content than the fibrous cortex[16]. However, the large differences in chemical reactivity between cuticle and cortex are probably due more to differences at the molecular and higher levels of organization than to differences in chemical composition.

I thank Dr. M. Lipson for suggesting this line of work, Mr. J. Delmenico for advice on dyeing and microscopy, and various colleagues for helpful discussions. Mr. H. Groll has rendered valuable technical assistance.

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THICKNESS OF THE EARTH'S CRUST IN ANTARCTICA

By F. F. EVISON, C. E. INGHAM and R. H. ORR

Department of Scientific and Industrial Research, New Zealand

ANTARCTICA has always been regarded as a continent by virtue of its size, but recent soundings have revealed that the ice-cap extends well below sea-level in many places, perhaps by as much as 2,000 metres. Whether the surface of the rock in such areas would remain submerged if the ice were to melt is largely a question of the ensuing isostatic adjustment. A more direct means of verifying the continental status of Antarctica is to determine the thickness of its crust, for all the established continents have a crustal thickness of 30–40 km. or more, in contrast to thicknesses of 5–15 km. in oceanic regions. The continental type of crust may be readily distinguished from the oceanic type by a study of the dispersion of earthquake waves travelling in the crustal layers, provided that suitably located shocks and seismograph stations are available. Dispersive waves from an earthquake of September 9, 1957, with epicentre (Fig. 1) in the south-east Indian Ocean (47$\frac{3}{4}$° S., 101° E.), were recorded at Scott Base and Hallett Station after traversing Antarctica for approximately 2,000 km., that is, about half the total path. An analysis of these waves has shown that the thickness of the crust in eastern Antarctica is about 35 km.; thus the existence of a true antarctic continent is confirmed.

The analysis was facilitated by a study of records of the same earthquake at Mirny, which indicated further that the thickness of the crust beneath the south-east Indian Ocean is about 9 km. The stations from which these results have been obtained were participating in the antarctic programme for the International Geophysical Year. Columbia University seismographs were used at Hallett Station (U.S.A.–N.Z.), Benioff seismographs at Scott Base (N.Z.) and Kirnos seismographs at Mirny (U.S.S.R.).

The wave-paths, shown in Fig. 1, were peculiarly favourable for the present study. The waves arrived well dispersed at Scott Base and Hallett Station, and the dispersion was influenced to a suitable extent by the segment of the path across Antarctica. Close similarity could be assumed between the oceanic structure affecting these paths and that for the path to Mirny. Although all the paths were rather shorter than would ordinarily suffice to prevent confusion among different types of wave, the directions of arrival were nearly ideal. Thus Rayleigh waves were

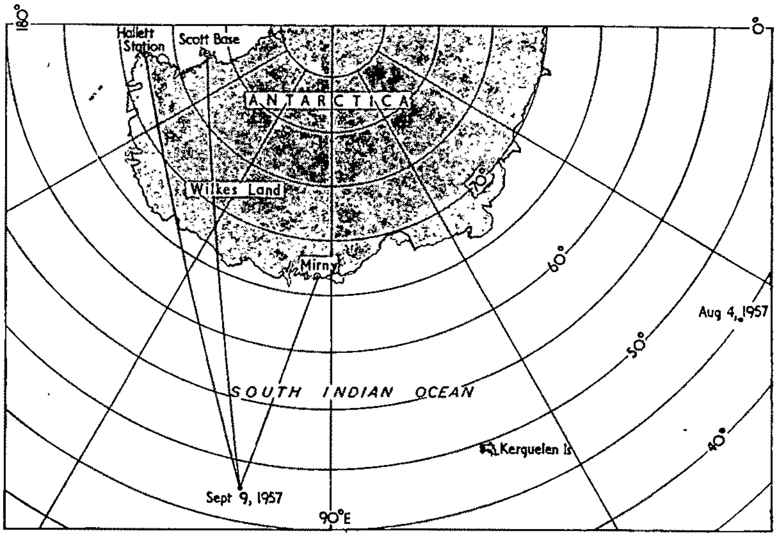

Fig. 1. Wave paths from earthquake epicentre to seismograph stations. (Polar stereographic projection)

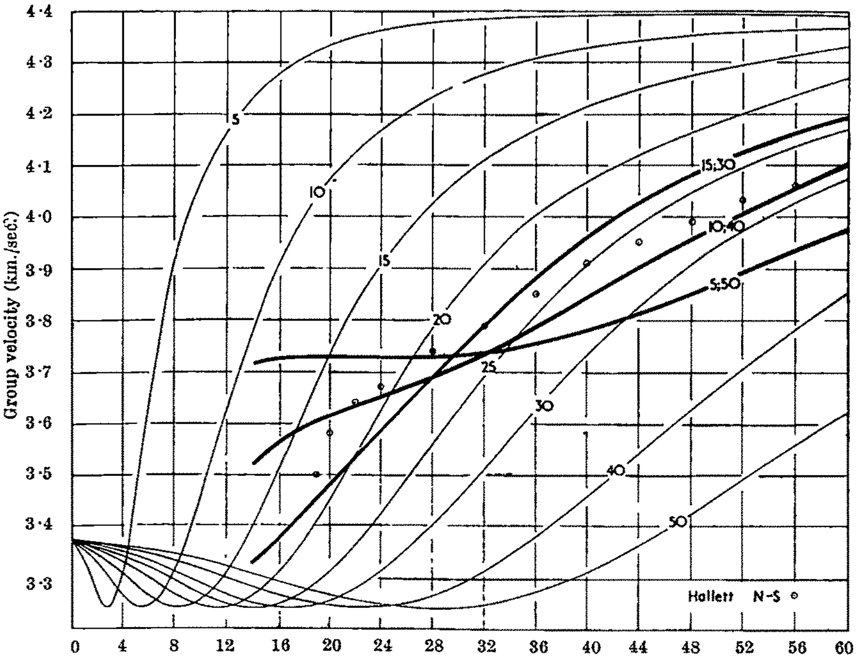

Fig. 2. Love wave dispersion. Theoretical curves are shown for crustal thicknesses from 5 km. to 50 km., with the following seismic constants. Shear velocities: crust, 3·47 km./sec.; mantle, 4·50 km./sec. Density ratio (mantle/crust), 1·283. The heavy curves are for composite paths, with one-half of the path at each of the thicknesses shown

clearly selected by instruments recording the east–west component at Scott Base and Hallett Station, and by the north–south instrument at Mirny, as well as by all the vertical instruments. Likewise, the Love wave was well recorded by the north–south instrument at Hallett Station; but the constants of the north–south instrument at Scott Base made it unsuitable for recording Love waves, and the path to Mirny was too short. The dispersion observations were analysed in the usual way[1], and interpreted by comparison with theoretical results. A three-layer model was adopted for the oceanic segment of the path, and a two-layer model for the land segment. The seismic velocities and densities of the crust and mantle respectively were assumed the same for Love and Rayleigh waves, and also for the oceanic and land segments.

The results for the Love wave recorded at Hallett Station are shown in Fig. 2. The family of theoretical curves was derived from parameters computed by Stoneley[2], each curve indicating the variation of group velocity with period for a particular crustal thickness. None of these curves approximates to the plotted observations, but a rather close fit is obtained by combining a pair of curves so as to allow for different thicknesses in the two segments of the path. With the segments equal in length, the composite group velocity for any period is the harmonic mean of the group velocities pertaining to each segment. Three such composite curves are shown in Fig. 2, from which it appears that the required crustal thicknesses are rather less than 40 km. for the antarctic segment and rather more than 10 km. for the oceanic segment.

The Rayleigh waves recorded at Scott Base, Hallett Station, and Mirny are analysed in Fig. 3 and provide an independent and rather more strongly supported solution. For an oceanic path the dispersion of Rayleigh waves differs from that of Love waves in being influenced by the liquid layer; thus two distinct families of curves are needed in considering a composite path. But the path to Mirny may be taken as purely oceanic, so in the present case a separate solution is obtained for the oceanic crust. A satisfactory fit to the Mirny observations was achieved by assuming a ratio of 2 : 1 between the crustal thickness and the depth of liquid, the actual values obtained being 9 km. and 4½ km. respectively. The latter value is consistent with the mean depth of water of 3·8 km. estimated from the bathymetric chart[3]; for studies of dispersion in the Pacific and Atlantic Oceans[4] have shown that the liquid layer usually includes unconsolidated bottom sediments to a

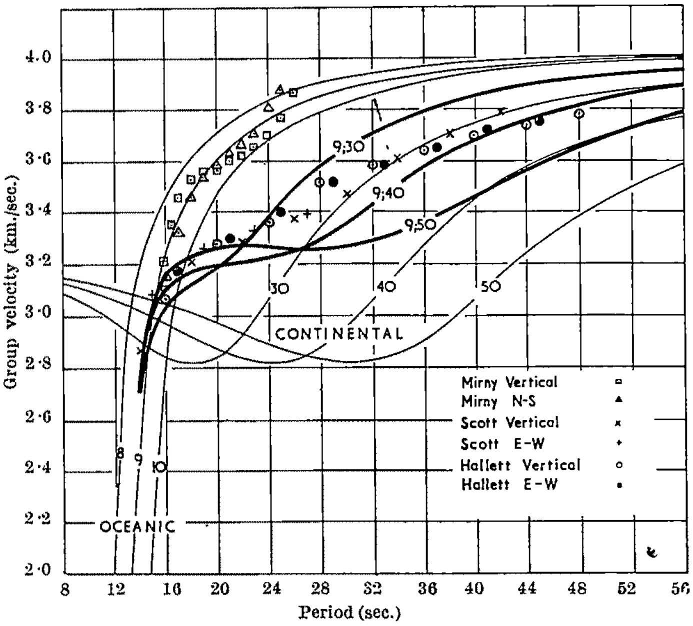

Fig. 3. Rayleigh wave dispersion. Theoretical oceanic curves are shown for crustal thicknesses of 8, 9 and 10 km., with depths of water equal to one-half the crustal thickness in each case. The continental curves are shown for crustal thicknesses of 30, 40 and 50 km. The following seismic constants were assumed, in addition to those of Fig. 2. Compressional velocities: water, 1·52 km./sec.; crust, 6·01 km./sec.; mantle, 7·79 km./sec. Density ratio (crust/water), 2·65. The heavy curves are for composite paths, with one-half of the path at each of the thicknesses shown

thickness of 0·5–1·0 km. From the composite curves in Fig. 3 it is concluded that the thickness of the crust of Antarctica is about 35 km.

The estimated values of crustal thickness, although derived from a single earthquake, receive support from the consistency that has appeared in the results for Love waves and Rayleigh waves. The method does not offer a high degree of precision, however, because of the simple models that must be assumed in order to keep the labour of computation within reasonable limits. A preliminary analysis has been made for a second earthquake, which occurred on August 4, 1957, in the south-west Indian Ocean (45° S., 35° E.) (see Fig. 1); this also indicates a thickness of about 35 km. for the crust of Antarctica. Analyses are in hand extending this study to other sectors of Antarctica, and the results will be published in full elsewhere.

This work has been made possible by the efforts of the New Zealand International Geophysical Year antarctic party under the supervision of Dr. T. Hatherton, chief scientist. We also desire to acknowledge the courtesy of the Institute of Physics of the Earth, Moscow, in providing a copy of the Mirny records.

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RESPONSES OF SEEDLINGS TO EXTRACTS OF SOYBEAN NODULES BEARING SELECTED STRAINS OF *RHIZOBIUM JAPONICUM*

By HERBERT W. JOHNSON, URA M. MEANS and FRANCIS E. CLARK
Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland

ERDMAN *et al.*[1] reported that some varieties of soybeans (*Glycine max* (L.) Merrill) develop chlorosis when nodulated with selected strains of *Rhizobium japonicum*, whereas other varieties do not. Johnson *et al.*[2] obtained differential responses of soybean genotypes to various environmental conditions and succeeded in producing chlorosis in varieties previously considered resistant by varying nutrient and substrate conditions. Johnson and Clark[3] used approach grafts between resistant and susceptible varieties to demonstrate that resistance or susceptibility is conditioned by the rootstock. They also found that chlorosis appeared in a difficultly nodulating genotype only after root nodules developed. They concluded that the substance causing chlorosis originated in the nodule.

In previous work the effects of treatments on chlorosis were evaluated in terms of the responses of the soybean genotypes cultured as host plants. An observed effect could have been due to the response of the soybean genotype to the treatment, a response of the bacterial genotype, or both. The experimental techniques employed did not permit separation of these effects. Objectives of the present work were to develop a technique for evaluating the production of the chlorosis-inducing substance independently of the symptoms of the top portions of the nodule-bearing plants and to test the effects of the substance on other plant species.

Nodules from chlorotic soybean plants inoculated with chlorosis-inducing *R. japonicum* strain 76 and from normal plants inoculated with strain 31 were used as source material. Host plants were of the Lee variety. It should be noted, however, that similar research with other bacterial strains and soybean varieties has demonstrated that results to be reported are not peculiar to the source materials of this study. In preliminary work, weighed amounts of fresh nodules were macerated in a crucible in measured quantities of water and the suspension filtered. Such filtrates supported luxuriant growth of micro-organisms, and their chlorosis-inducing properties deteriorated rapidly. Filtrates autoclaved at 120° C. for 20 min. remained fully effective in inducing chlorosis, and once autoclaved they could be stored for several months at room temperature without measurable deterioration in activity. Sterile and initially highly active extracts deliberately contaminated with small quantities of soil lost their chlorosis-inducing activity during the first week after contamination. Extracts prepared from nodules frozen for as long as six months or from nodules dried in the greenhouse for as long as one month were not measurably different in activity from those prepared from fresh nodules.

For the tests reported here, nodule extract was made by blending fresh nodules in water in a Waring-type blendor in the proportion of 1 gm. of fresh nodules to 25 ml. of water. This stock extract was autoclaved at 120° C. for 20 min. and stored aseptically until used.

In testing for seedling responses, seeds were surface-sterilized or treated with 'Spergon', germinated in sand, and, at emergence, seedlings were transferred to vials containing the test solution. The capacity of the vials varied from 4 to 10 ml. depending on the size of the seedlings involved. These small reservoirs suffered depletion because of evaporation and consumptive intake of water. Additional test solution was added to them for replenishing the supply when necessary.

Chlorosis of the unifoliate and the first trifoliate leaves of soybean seedlings was scored from 1 (slight) to 4 (severe). Plants of other species were scored on the same scale and at comparable stages of development. Species tested are listed in Table 1.

Extracts from nodules of normal green soybean plants nodulated with strain 31 were included as checks in all experiments. None of the many seedlings grown in them developed chlorosis. To facilitate presentation of results, nodules or extracts from normal plants are referred to as the *N* type and those from chlorotic plants nodulated with strain 76 as the *C* type. Concentrations of the extracts are stated as fractions, indicating 1 gm. of fresh nodule/ml. of water.

Soybean seedling responses. Both *N* and *C* extracts more concentrated than 1/50 were toxic to all soybean seedlings grown in them, and little chlorosis developed. The toxic effects appeared to be due primarily to damage of the root system. Development of branch roots was inhibited, and the main root quickly developed a greyish-brown water-soaked appearance.

Growth was retarded in 1/50 extracts, but slight chlorosis of the unifoliate leaves and moderate chlorosis of the first trifoliate leaves developed on seedlings grown in *C* extract. Seedlings of the highly susceptible Lee variety and those of the slightly susceptible *CNS* variety were equally chlorotic in the 1/50 *C* extract. In contrast, chlorosis of Lee in 1/100 concentration was as severe as in the 1/50, but *CNS* was free of chlorosis. In some lots of *C* extract, the Lee variety was as chlorotic in 1/200 as in 1/100 concentration; in other lots, it developed no chlorosis at 1/200, and only moderate chlorosis at 1/100.

Responses of other plants. Seedlings of 37 plant species in addition to soybeans were grown in 1/100 nodule extracts in the same manner as soybeans and scored for chlorotic response. Although all were evaluated on at least two occasions, the results do not necessarily indicate that the species which developed no chlorosis are resistant to the causative substance. All species were handled uniformly without effort to develop a technique particularly suited to a given species. It is quite possible that the technique employed was a limiting factor with some species but not with others.

Responses of the 38 species employed are summarized in Table 1. Of the seven species showing severe chlorosis, *Sorghum vulgare* showed onset of chlorosis two days after initial exposure, and the other six after three days. Average number of days for onset of chlorosis for the thirteen species listed as moderately chlorotic was 8·2, and for those listed as slightly chlorotic, 10·3 days. Seedlings of *Phaseolus vulgaris* and *P. lunatus* developed a mottled appearance after three weeks of exposure.

Chlorotic and normal seedlings of *Trifolium pratense* and *Sorghum vulgare* are shown in Fig. 1. Characteristics of seedling chlorosis for species other than soybeans were in general similar to those previously described for soybeans[2]. The chlorosis was restricted to new growth. Normal green leaves once fully formed did not develop chlorosis afterwards. In *S. vulgare* chlorosis developed first at the base of the second leaf and the entire leaf became chlorotic within a few days, but the first leaf remained green.

Damage to roots and general retardation of growth similar to those described for soybeans were observed to varying degrees with other species. *Carthamus tinctorius* and *Gossypium hirsutum* appeared to be particularly susceptible, although neither developed chlorosis. Growth of soybeans in fresh *C* extract that had been filtered through a bacteriological-grade sintered glass filter was more rapid and chlorosis more severe than that of seedlings in unfiltered extract. However, this was not true for autoclaved extracts. Root damage caused by autoclaved extracts was not associated with various fractions separated by filtering or centrifuging.

Table 1. SUSCEPTIBILITY OF SEEDLINGS OF VARIOUS SPECIES TO A CHLOROSIS FACTOR IN SELECTED SOYBEAN NODULES

Severely chlorotic
  Allium cepa, Digitaria sanguinalis, Sesamum indicum, Sorghum vulgare, S. vulgare (Sorgo), *Trifolium pratense, T. subterraneum.*
Moderately chlorotic
  Cucumis sativus, Cucurbita pepo, Glycine max, Linum usitatissimum, Lotus corniculatus, L. uliginosus, Medicago sativa, Oryza sativa, Sorghum sudanense, Trifolium incarnatum, Vigna sinensis, Zea mays, Zinnia elegans.
Slightly chlorotic
  Avena sativa, Lycopersicon esculentum, Vicia villosa.
Questionably chlorotic
  Phaseolus lunatus, P. vulgaris.
Non-chlorotic
  Amaranthus retroflexus, Arachis hypogaea, Brassica oleracea var. *acephala, B. rapa, Carthamus tinctorius, Festuca rubra, Gossypium hirsutum, Hordeum vulgare, Lolium multiflorum, Lupinus angustifolius, L. luteus, Raphanus sativus, Triticum aestivum.*

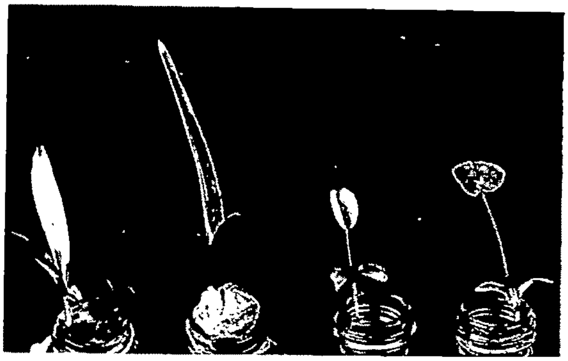

Fig. 1. Seedlings in 1/100 extracts of nodules from chlorotic and normal soybean plants. Left to right: *Sorghum vulgare*, chlorotic and normal; *Trifolium pratense*, chlorotic and normal

The several experiments indicate that the water-soluble substance causing chlorosis is an entity differing from the substance causing toxicity.

S. vulgare seedlings exposed to 1/50 *C* extract for as little as 8 hr. before transfer to distilled water showed slight chlorosis by 48 hr. after the original exposure but recovered by the end of four days. Seedlings left in the extract for 24, 28, 32, 48, 50, 56, 72, 76 and 80 hr. developed progressively more intense chlorosis, some of which persisted until the termination of the experiment on the twelfth day. With 1/100 and 1/200 concentrations, the minimum exposure time was 24 hr. rather than 8 hr.

S. vulgare seedlings in mixed extracts containing varying amounts of *N* and *C* nodules developed chlorosis in proportion to the concentration of *C* nodules in the mixture. A given concentration of *C* nodules in the mixture resulted in chlorosis equal to that of the same concentration of *C* nodules alone. Chlorosis of seedlings in 1/100 *C* extract in distilled water was comparable in speed of onset and severity with that of seedlings in 1/100 *C* extract in complete nutrient solution. As with soybean plant cultures, there was no evidence that chlorosis when present was due to lack of essential nutrients in the substrate.

Other substances reported to cause chlorosis in plants were evaluated using the techniques of the present study. The chlorosis produced by nodule extracts does not appear similar to that produced by streptomycin sulphate[4] or by biuret and ammonium nitrate. With soybean nodule extracts, negative results were obtained from placing extract in leaf whorls of *Zea mays* and *S. vulgare* seedlings in the manner described by Curtis[5].

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Phase Characteristics of Radio Signals received via the Ionosphere

A RADIO wave after reflexion from the ionosphere may be considered to consist of a specular component and a varying diffracted component[1], the latter being the result of random scattering from a large number of moving irregularities. If the effect at a point on the ground is considered, the diffracted component may be regarded as a cone of radiation having its apex at the point on the ground and its base spread over a large area of the ionosphere. The specular component appears as a coherent wave the arrival path of which is assumed to be along the axis of the diffraction cone and changes direction slowly compared with the fading rate of the signal[2]. Information concerning the amplitudes of the specular and diffracted components of a radio wave and of the angular spread of the cone of rays forming the diffracted component is an important factor in the design of some types of receiving aerials. This information may be obtained from the probability distribution of the phase-difference between the two signals which result from the reception of the radio wave at two aerials spaced apart by a known distance.

By spacing the aerials so far apart that the spatial phase-correlation in the diffracted component in the signals at the two aerials is negligible, the ratio of the power in the specular component to that in the diffracted component may be measured. Phase measurements provide a more sensitive method of detecting small specular components than amplitude measurements since the Rayleigh distribution of amplitude is not altered materially by the presence of a specular component unless its power is several times that of the diffracted component[1].

Using a result given by Rice[3] in his work on random noise, it may be shown that the combined probability distribution for the phase φ and amplitude R of the signal at one aerial is :

$$p(R,\ \varphi) = \frac{b^2 R}{\pi} \exp[-b^2 (R^2 + 1 - 2R \cos \varphi)]$$

where amplitudes are measured in terms of the specular component and where b^2 is the ratio of specular component power to diffracted component power. The phase-probability distribution may then be shown by integration to be :

$$p(\varphi) = \frac{1}{2\pi} \exp(-b^2) \times$$

$$[1 + b\pi^{1/2} \exp(b^2 \cos^2 \varphi) \cos \varphi \{1 + \operatorname{erf}(b \cos \varphi)\}]$$

An approximation to this distribution may be made by using a normal distribution with the skirts outside the range of variate $-\pi < \varphi \leqslant \pi$ folded over and added to the distribution within this range. The (unrestricted-variate) probability distribution for the phase-difference φ_d between two aerials is then a similar distribution having twice the variance of the unrestricted-variate distribution for one aerial if the correlation is zero.

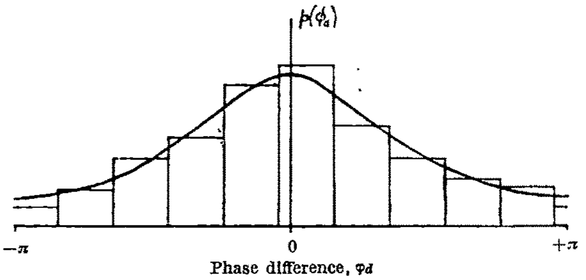

Fig. 1. Theoretical and measured phase probability distributions. Aerials widely spaced (26·0λ). WWV, 20·00 Mc./s. 1400 hr. February 10, 1958

With closer spacing between the aerials, measurements of the phase correlation between the signals enable the angular spread of the cone of rays forming the diffracted component to be estimated. The theory used in this case is similar to that used for direction-finding studies[4,5] with a correction applied to allow for the effects of the specular component.

Phase measurements of the type described have been made using a phase-distribution analyser. In this apparatus, the signals at the two aerials are changed in frequency to 1 kc./s. in three stages, common oscillators being used in order to preserve the phase difference between the signals. The 1-kc./s. signal derived from the first aerial is squared and differentiated to produce a pulse each time the waveform passes through zero in a positive direction. This pulse is arranged to open a gate which closes automatically after an interval of 0·1 msec. The closing of the first gate opens a second gate which also closes automatically after a similar interval, and this process is repeated through a chain of ten gates. The 1-kc./s. signal derived from the second aerial also causes a pulse to be generated each time the waveform passes through zero in a positive direction. This pulse is applied simultaneously to the ten gates associated with the first aerial and it will pass through one of the gates, depending on the phase difference between the signals at the two aerials. Ten counter units, each associated with one of the gates, are arranged to operate from the pulses passing through the gates so that after a suitable interval the numbers

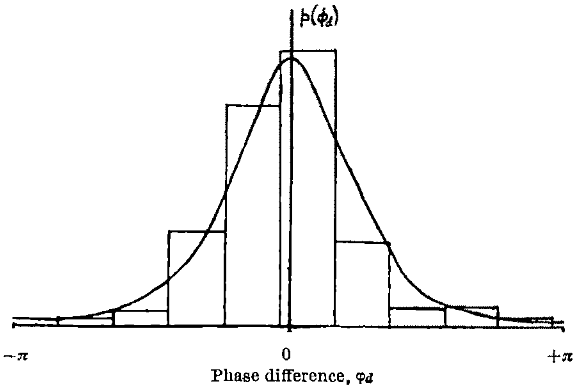

Fig. 2. Theoretical and measured phase probability distributions. Aerials close together (2·2λ)

displayed by the counters show the phase-difference distribution on a grouped-frequency basis.

The main advantage of this type of apparatus is the high rate of sampling which enables the probability distribution for several different aerial spacings to be determined before the effects of ionospheric tilting[2] produce significant changes in the statistical properties of the signal. Moreover, the distributions are displayed directly without the necessity for analysing chart records.

Typical 1-min. sample distributions are shown in Figs. 1 and 2 together with the theoretical distributions. The measurements were made on the standard frequency transmitter WWV (Washington, U.S.A.) operating on 20 Mc./s. at a time when a musa[6] receiver operating on 19·82 Mc./s. indicated that the transmission was virtually single-path. In Fig. 1, the peaking of the distribution was caused by the effects of a specular component alone. In Fig. 2, correlation in the diffracted component reduced the spread of the distribution still further. In the example quoted, the ratio of specular to diffracted power (b^2) was found to be 0·25, while the standard deviation of the angular spread of the diffraction cone in the vertical plane was approximately 6°. The vertical arrival angle derived from the means of the phase-difference distributions was 15°.

D. W. MORRIS
C. J. HUGHES

Post Office Engineering Department,
Research Station, Dollis Hill,
London, N.W.2.
Dec. 5.

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Electric Strength and High-Field Conduction Current in *n*-Hexane

SEVERAL investigations of the electric strength and high-field conduction of *n*-hexane and similar hydrocarbon liquids have been made in recent years, and reproducible measurements have been reported, for example, by Lewis[1], Sharbaugh, Crowe and Cox[2], and by House[3]. New experiments of mine, however, indicate that nearly all these results were strongly influenced by the presence of dissolved oxygen.

Samples of dry filtered *n*-hexane were prepared using techniques described earlier[1,3] with the important addition that the liquid could be well degassed by evacuating the closed distillation system to about 10^{-2} mm. mercury with the liquid cooled to -90° C. The liquid could be maintained in the test cell in this degassed state or saturated with dry gas as required. The electric strength and conduction measurements were made with highly polished spherical electrodes (1 cm. diameter), 50μ apart, using either direct or 1·5 μsec. rectangular pulse voltages and adopting similar techniques to those given in refs. 1–3.

Typical results chosen from a large number of repeatable tests are given in Table 1 and demonstrate that when the air or oxygen content of the liquid is large the strength is high and the coefficient of variation small. In these conditions the results are in close agreement with those reported earlier[1,3]. With degassed and nitrogen-saturated liquid the mean strengths are much lower, although the first few measurements with degassed liquid and fresh electrodes invariably gave high strengths. It was possible to change the liquid in the test cell from a degassed to an oxygenated state and vice versa several times with the electrodes unchanged and still maintain the strengths quoted in Table 1. It is important to note that the strength of a liquid with high air content showed no dependence upon pressure, in agreement with previous observations[1]; but for degassed liquid the strength decreased rapidly as the pressure was reduced below the atmospheric value.

Table 1. THE INFLUENCE OF GAS CONTENT ON THE ELECTRIC STRENGTH OF *n*-HEXANE. VALUES QUOTED ARE THE MEANS OF NOT LESS THAN TEN CONSECUTIVE MEASUREMENTS

Test voltage	Test liquid	Electrodes	Mean strength (MV./cm.)	Coefficient of variation (per cent)
d.c.	Degassed	Chromium	0·88	17·1
d.c.	High air content	Chromium	1·33	6·4
d.c.	High oxygen content	Chromium	1·33	6·2
d.c.	High nitrogen content	Chromium	0·89	10·7
1·5 μsec. pulse	High air content	Stainless steel	1·55	12·3
1·5 μsec. pulse	Degassed	Stainless steel	0·90	5·5

The air content also influences the high-field conduction current. With degassed liquid the current fluctuated more and more violently as the field was raised and showed little tendency to become stabilized with time. On the other hand, a liquid with a high air content at atmospheric pressure was found to have a stable conduction current which could be measured at fields right up to 1·2 MV./cm. After the first voltage application reproducible current-voltage curves as in Fig. 1 could easily be obtained. It can be seen that the current is about a quarter of that reported by House[3] for the same electrode conditions. Even with hexane of commercial purity, curves almost identical to those given by House can be obtained provided the air content is large, without the necessity of a long conditioning process.

It is concluded that the oxygen content plays a vital part in determining the electric strength and conductivity of *n*-hexane. Experiments are proceeding to determine more precisely the role of oxygen

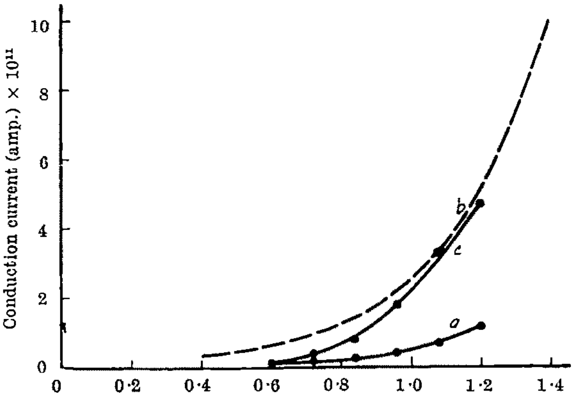

Fig. 1. Conduction current in *n*-hexane as a function of mean stress for a 50-μ gap and stainless steel electrodes. *a*, Spectroscopic grade hexane, air saturated at 760 mm. mercury; *b*, spectroscopic grade hexane, as reported by House (ref. 3); *c*, commercial grade hexane, saturated with air at 760 mm. mercury

and other gases in the breakdown processes, and the results will be published in due course. The present results are sufficient to show, however, that most of the high and reproducible values of the breakdown strength reported hitherto referred to *n*-hexane containing a substantial proportion of dissolved oxygen.

I wish to thank Prof. M. W. Humphrey Davies for the facilities made available to me. Thanks are also due to Dr. T. J. Lewis and other colleagues in the Department.

A. M. SLETTEN

Electrical Engineering Department,
Queen Mary College,
Mile End Road,
London, E.1.
Dec. 15.

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A Proposed Method for the Measurement of the Velocity of Light

THE precision of optical methods of measuring the velocity c of electromagnetic radiation in free space is restricted by the upper limit of the frequency at which a light wave may be amplitude-modulated. Bergstrand[1], in his recent measurements, used a modulation frequency of 10 Mc./sec. and consequently his base-lines were several km. long. The highest modulation frequency so far reported seems to be 300 Mc./sec. by Rao and Murty[2] using diffraction by ultrasonic waves in a crystal. It would be desirable to increase this limit so that an optical standard of length could be used directly in a determination of c. The correlation of photons in coherent light, which now seems well established[3], eliminates the necessity for a direct modulation of a light source. Two wave trains of optical frequencies ν_1 and ν_2, falling on a photosensitive surface, will give[4] a component in the photo-current at a frequency $(\nu_1 - \nu_2)$. If the wave trains are divided at a half-silvered mirror and fall on two photocells P_1 and P_2, the outputs S_1 and S_2 of these cells at a frequency $(\nu_1 - \nu_2)$ may be added and will interfere to give an output S_3, the amplitude of which depends on the relative phases of the two signals S_1 and S_2. It may readily be shown that if P_1 is kept fixed and P_2 is moved radially away from the source, the amplitude of S_3 will have minima separated by a distance $\frac{1}{2}c/(\nu_1 - \nu_2)$ if the source can be considered to be a distant point.

At the moment the method is impracticable because the signal-to-noise ratio achievable with existing light sources would be far too small. The proposed development[5] of a maser working in the visible region would, however, yield a light source with a very much smaller frequency width than has hitherto been obtained. Ideally, for the application suggested here, the source should emit light in two narrow bands $(\nu_1 - \nu_2)$ apart, each having a frequency width very much narrower than $(\nu_1 - \nu_2)$. The latter criterion, according to the example taken by Schawlow and Townes[5], could, if $(\nu_1 - \nu_2)$ were of the order of 1–10 kMc./s., be achieved in the optical maser. The separation of the two components could be obtained by the Zeeman splitting of the line emitted by the maser. The use of such a high value of $(\nu_1 - \nu_2)$ precludes the use of the conventional photomultiplier ; but there seems no reason why a suitable photosensitive device[4] should not be designed for use at such frequencies.

The ultimate precision of this proposed method depends on the signal-to-noise ratio which can be achieved when : (*a*) the sizes of the light source and of the detecting surfaces are restricted within narrow limits, and (*b*) the frequency $(\nu_1 - \nu_2)$ is defined by a narrow-band receiver. Successful operation of the optical maser would allow the precise determination of c in the visible region over much shorter baselines, and possibly with higher precision than has hitherto been achieved. It would also provide a light source which would allow an even more convincing demonstration of photon correlation than that of Twiss, Little and Hanbury Brown[3].

J. H. SANDERS

Clarendon Laboratory,
Oxford.
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An Experimental Method for Diffusion and Extraction Studies across the Liquid–Liquid Interface

THE prototype apparatus shown schematically in Fig. 1 offers a promising experimental approach for diffusion and extraction studies across the interface between certain aqueous–organic systems uncomplicated by diffusion control in the adjacent bulk phases. It may also prove an effective probe of factors which influence the behaviour and 'structure' of the interface. The apparatus is operated in the following way. The substance being extracted (with tracer) is dissolved in 1 cm.^{3} of static aqueous phase placed so the aqueous surface formed at the bottom of the 'Teflon' slit (0·25 in. × 0·001 in.) is oriented lengthwise across the width of the rim, and about 0·006 in. above the wheel. Individual organic drops, at 1–5 drops/sec., are dropped on the 'Teflon' rim spinning at 10–200 r.p.m. Each drop is squeezed past the slit where it makes brief 'contact' with the aqueous phase before being almost entirely dragged away from the slit, wiped off, and collected at the bottom of the wheel. The activity/cm.^{3} of substance in the extract multiplied by the rate of production of drops is a measure of the 'apparent extraction rate', a parameter sensitive to the concentration of constituents involved in the extraction process.

In a study at 100 r.p.m. of the simultaneous extraction of radioactive iron(III) and cæsium(I) from a 1 M nitric acid/water solution with pure tributyl phosphate, the ratio of the activity of cæsium to that of iron in the extract was 0·80 ± 0·02 compared to the original value in water of 1·18 ± 0·03. The activity/cm.^{3} in this extract was about 10^{-3} times that of the aqueous phase, but it was about ten times more than is picked up by tributyl phosphate in a single equilibrium extraction with the same volume. These results indicate that a 'stable' interface with diffusive flow across it was achieved and that a differential rate of extraction in favour of iron(III) over cæsium(I) was obtained. Furthermore, the ratio of cæsium to iron in the extract differed markedly from the equilibrium value

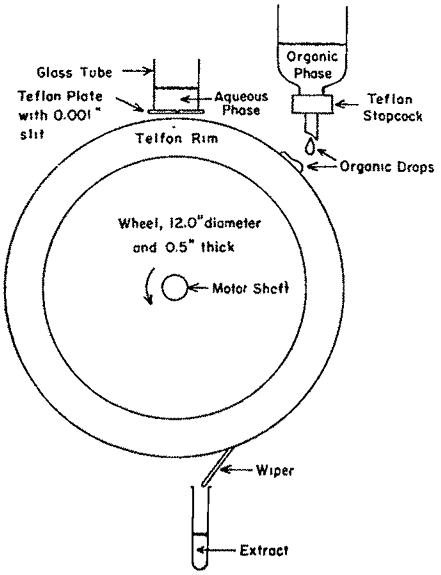

Fig. 1. Schematic cross-section of 'steady-state' interfacial extraction apparatus

of 2·0 for this phase, which is good evidence that the extraction depends on irreversible processes. Using tributyl phosphate/kerosene mixtures for the organic phase, the apparent extraction rate of iron(III) is dependent on the concentrations of iron(III), nitric acid and tributyl phosphate. For example, the rate is approximately fifty times greater using pure tributyl phosphate than using pure kerosene under similar conditions. These qualitative results indicate the feasibility of determining the form of the kinetic rate expression and testing the mechanism of extraction processes by this approach.

Thus it is possible to maintain an aqueous-organic interface within a 'Teflon' slit while mechanically pulsing it as frequently as every 0·2 sec. with a fresh drop of organic phase. Each drop apparently perturbs the interfacial region for a period which can be varied easily from 10^{-1} to 10^{-3} sec., during which mechanical agitation in the bulk phases adjacent to the interface must occur. These actions help to prevent diffusion in the bulk phases from limiting diffusion across the interface. It is believed that the net effect of frequent pulsing is to establish a relatively constant gradient of concentration, with a 'sink' on the organic side, so that diffusion across the interface is essentially unidirectional. The periodic pulsing of successive drops appears to be quite crucial to the success of this method, for the interface is unstable with a continuous flow of organic phase.

For processes between a two-phase liquid system, the method is somewhat analogous to the pulsing methods described by Eigen[1] for homogeneous systems. If it can be perfected, it may be possible to measure extraction rates and the form of the rate expressions for diffusion in both directions across the interface and thus obtain ratios of rate constants independent of uncertain quantities such as 'phase contact time' and the detailed geometry of the interface. Such rate constant ratios should be related to the distribution coefficients obtained in equilibrium extractions.

The simple geometry of the apparatus lends itself to certain modifications to make it an even more useful probe of interfacial phenomena. For example, the extract can be recirculated for slower diffusion processes like those through ion-exchange and biological membranes. It can also be adapted for extraction studies with a temperature gradient imposed across the interface. One last feature should be mentioned; because 'Teflon' is a non-conductor and can be charged, there exists the possibility of pulsing the interface with a variable electric field and of testing this effect on the extraction process. The instrument is now being modified for a more comprehensive investigation of its potentialities.

I am indebted to the Analytical Chemistry Division, ORNL, Oak Ridge, Tennessee, for the construction of the apparatus and the use of its facilities to obtain these experimental results while I was a summer participant supported by the Oak Ridge Institute of Nuclear Studies from June to September 1958. I also wish to thank B. A. Soldano, W. Baldwin and D. Harrison for valuable discussions.

THOMAS W. MARTIN

Department of Chemistry,
Vanderbilt University,
Box 1506,
Nashville 5, Tennessee.
Oct. 16.

[1] Eigen, M., *Disc. Farad. Soc.*, 17, 194 (1954).

Measurement of the Flocculation of Suspensions

AT the Third International Rheological Congress held in Germany in September 1958, Prof. R. Fahraeus, in a paper entitled "The Influence of the Rouleau Formation of the Erythrocytes on the Rheology of the Blood", described a method which he had developed for measuring the degree of coagulation present in a blood sample. The procedure was to filter the blood through a stack of filter papers and to measure the quantity retained on each. The greater the coagulation of the blood, the less the number of papers through which it could penetrate.

I have recently tried this technique for measuring the degree of flocculation of a clay suspension. 100 ml. of a 2 per cent suspension (by weight) was poured into a pressure filter which contained a stack of papers 9 cm. in diameter and a pressure of approximately 15 lb./sq. in. was applied. At the top of Fig. 1 may

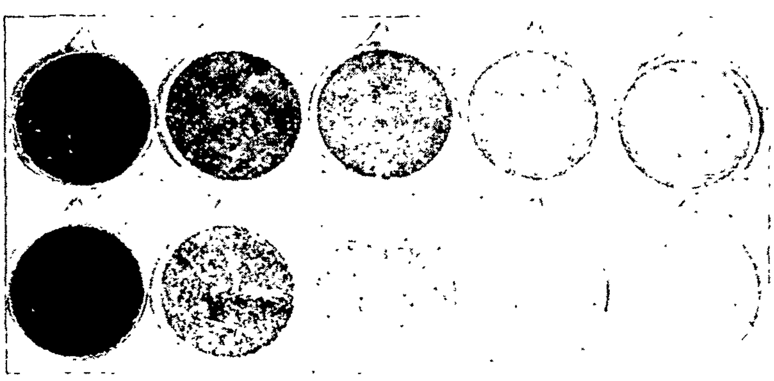

Fig. 1

be seen the successive papers obtained with a suspension (in distilled water) of a coal-measure shale from the Grove seam in the West Midlands. At the bottom are papers obtained after 5 ml. of a 1 per cent solution of potash alum had been added to 100 ml. of the same suspension in order to produce flocculation of the solid matter. The reduction in the penetration of the filter papers (Whatman No. 4) is quite evident and should be amenable to quantitative measurement.

Thus it appears that Prof. Fahraeus's technique could offer a method not only for measuring the coagulation of blood but also for the flocculation of shale and clay suspensions.

R. L. Whitmore

Department of Mining and Fuels,
University of Nottingham.
Dec. 19.

Etch Pits on Calcite Cleavage Faces

This communication describes some of the effects observed on calcite cleavage faces after etching with dilute acid. Puchegger[1] has reported etch pits which formed a rib-like pattern on either side of scratch marks made on calcite. More striking features are described here.

Rhombohedral crystals, freshly cleaved from a large block of natural calcite, were etched and examined on each face in turn. Etching was carried out in 1 per cent nitric acid, after which the crystals were washed with distilled water, ethanol and carbon tetrachloride, and dried. Etching times varied from 5 sec. to 5 min. The crystals were examined and photographed on a Vickers projection microscope using oblique illumination by a mercury-vapour lamp with yellow-green filter.

The same general features were found on each face and no features were found to be peculiar to any single face or pair of opposite faces. Numerous etch pits were observed occurring singly, in small groups, and in lines of overlapping pits. No pits were observed on unetched faces. Three types of pit were observed; three-sided 'flat iron' pits depicted in Fig. 1*a*, referred to hereinafter as type 1; four-sided pits (Fig. 1*b*), type 2; and five-sided pits (Fig. 1*c*), type 3. Types 2 and 3 predominated. Steps were observed on the faces of many of these pits and may be seen in Fig. 1*d*. Some pits retain their shape for long etching times, others cease to increase in depth relative to the general surface-level after a few seconds etching and then only increase in area to give flat-bottomed pits, some of which may be seen in Figs. 1*a* and *b*. These pits eventually overlap others and fade out to leave a shadowy outline. New pits sometimes start to grow in the flat bottom of an old one. Some pits persist for several minutes etching time and become visible to the naked eye; such pits have very rounded sides. A few highly pitted regions were observed. They appear within 5 sec. etching and persist with little change in configuration for 3 min. or more (Fig. 1*e*). These pits were all of type 3; but in the figure dark shadow makes it difficult to distinguish the intersection of two of the faces.

Visible fracture planes in the crystal, both parallel to and along the diagonals of cleavage faces, etched into deep grooves (Fig. 1*f*) with a rib structure similar to but more pronounced than that observed by Puchegger[1]. These grooves sometimes contain a few deeper pits, as may be seen in Fig. 1*f*.

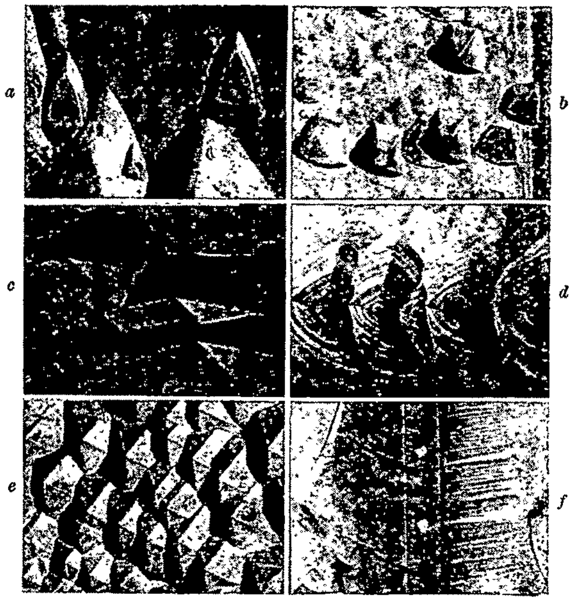

Fig. 1. *a*, Three-sided etch pits, type 1, 90 sec. etching; *b*, four-sided etch pits, type 2, 5 sec. etching; *c*, five-sided etch pits, type 3, 30 sec. etching; *d*, line of overlapping pits, 45 sec. etching; this line extended for more than 2 mm. on the crystal; *e*, highly pitted region, 60 sec. etching; *f*, etch groove at fracture plane—note width of ribbed region and pits in groove. (All *c*. × 100)

The fact that some pits lie in lines across the crystal (Fig. 1*d*) suggests that they are formed by preferential etching at the site of dislocations in the crystal[2]. The highly pitted regions would be regions of high disorder. The width of the ribbed region in Fig. 1*f* seems to indicate that slip along a fracture plane in the crystal disturbs a large region on either side of the plane.

The steps on a pit face make it possible to determine if that face is flat or curved, if it is presumed that all steps are parallel to the original surface before etching. All faces on pits of type 3 are flat, all pits of type 2 have at least one curved face, while all faces on pits of type 1 are curved. Pits of types 1 and 2 are probably degenerate forms of type 3 pits. Replacement of a pair of flat faces in type 3 by one curved face would give type 2; at the same time two other faces often become slightly curved. Type 1 pits would be formed from type 2 by continuing two faces to meet at a point.

It is difficult to envisage a mechanism whereby a five-sided etch pit can arise in a rhombohedral crystal. In view of the importance of etch pits to dislocation theory, I feel it is worth directing the attention of others to these effects at the present time.

I am indebted to Mr. W. T. Denholm for discussions.

H. Watts

Bonython Laboratory,
South Australian School of Mines and Industries,
Adelaide.
Dec. 12.

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A Micrographic Study of Wear of Graphite

The sheet-structure of graphite is well known[1]: upon microscopic examination of crystalline fragments, individual sheets exhibit some properties of a tough membrane when not torn transversely. Individually they may be lifted or peeled to uncover a flat surface, which is highly reflecting, and in thin layers transparent.

These properties make graphite ideally suited for microscopic observations of its wearing characteristics during the sliding process.

The details of this process for graphite had not been apparently discovered. For example, it was not known whether wear accrues from the mechanical action of edges, the adhesion through edge surfaces or across massive facial areas, the tooling action of disoriented crystals, or by other unexpected effects.

Observations have been made here on natural graphite crystals oriented on the stage of a microscope under bright field epi-illumination. Initially the basal plane of the crystal was mounted rigidly and held flat and normal to the incident light beam. With selected adjustments of the illumination, steps, faults and surface impurities became prominent, and slight disturbances to a shallow depth within the crystal were found to produce faint shadows indicating the nature and extent of the stresses or damage.

During this work at magnifications up to 320, the graphite faces were explored by metal micro-probes or polished needles using the smooth conical section near the tip. The geometry of the arrangement made possible the estimation of the real contact area in relation to the area visibly disturbed by the contact.

This disturbed area was found to be very much greater than that bounded merely by the contact dimensions of the probe. Upon application of pressure of the probe against the graphite, a few sharp shadow lines frequently developed within the graphite surface adjacent to the contact spot. These spread to the sides or in advance of the probe and travelled with it as it traversed the basal plane surface. These shadow lines were usually straight, and extended to distances as much as a hundred times the contact radius. Some were completely elastic, disappearing upon withdrawal of the probe or oscillating back and forth if the probe was made to vibrate gently upon the surface.

By interference microscopy it was found that the shadow lines in representative cases could be the boundaries of basal plane area which had undergone minute localized tilting near the contact region, amounting to a few hundred angstroms of tilt across the entire field of view.

These optical line patterns on the graphite undergoing rubbing are interpreted tentatively as fault or dislocation regions at the intersectional boundaries between original planes and disturbed planes. This interpretation implies reversible atomic separations transversely through the basal planes in patterns sufficiently broad to be observed as narrow lines with an optical microscope. Disturbances of this kind should involve a contribution to the frictional work, and they indicate one of the characteristic features in the sliding process which may precede the onset of wear.

The appearance of these optical line patterns emanating beyond the region of real contact suggests that the shearing and ploughing terms, generally accepted as descriptive of the main processes involved in sliding solids, may not be sufficient to describe the wear and friction occurring on the surfaces of lamellar solids. A new description of the graphite-wearing process following from the detailed microscopic observations will appear in due course.

ROBERT H. SAVAGE

General Electric Research Laboratory,
Schenectady, New York.

Nov. 18.

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Low-temperature Specific Heats of Body-centred Cubic Chromium–Iron and Chromium–Manganese Alloys

The electronic structure of the transition elements in the metallic state is not yet fully understood. It may be hoped that additional information with regard to the electronic specific heat coefficients and other physical properties of these elements, as well as of their alloys, will help in the interpretation of their structure.

On the basis of the band structure of the transition elements and of the usual interpretation of the electronic specific heat coefficient, it should be possible to trace the shape of the partially filled *d*-band, that is, the density of states as a function of the electron concentration, by determining experimentally the electronic specific heat coefficient γ for a series of solid solution alloys of a given crystal structure.

In the present work, low-temperature specific heats were determined for body-centred cubic binary solid solutions in the chromium–iron and chromium–manganese systems. Specific heats were measured in the temperature range of 1·6°–4·2° K. to an estimated accuracy of ± 2 per cent for most alloys. For a few alloys, where the specific heat depends very sensitively on the alloy composition, the accuracy may have been as low as ± 5 per cent. The alloy specimens were prepared by induction melting from electrolytically refined metals and homogenized by annealing for at least three days at 1,170° C. in a purified gas mixture of 92 per cent helium and 8 per cent hydrogen, and quenched to room temperature.

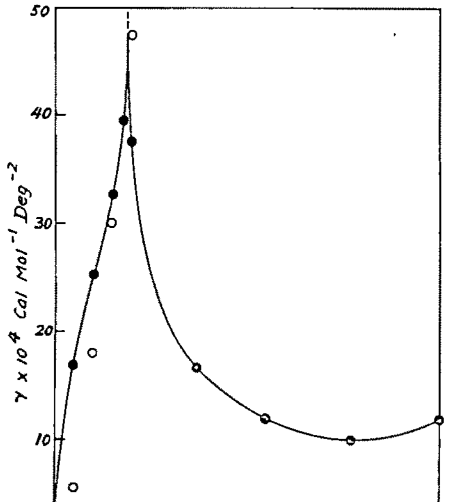

Fig. 1. Coefficient of temperature-linear term of low-temperature specific heat vs. electron concentration. ●, Chromium-iron alloys; ○, chromium-manganese alloys

The low-temperature specific heats were analysed by means of the usual C_v/T vs. T^2 extrapolation to $T = 0$, to obtain the coefficient γ of the temperature-linear term. These γ values are plotted in Fig. 1 as a function of the electron concentration. The γ for iron was measured and found to be in excellent agreement with the value reported by Keesom and Kurrelmeyer[1]. The γ for $Cr_{0\cdot44}Fe_{0\cdot56}$, as determined by Hoare and Matthews[2], is plotted in Fig. 1, and it fits very well the curve for chromium–iron alloys. A large peak occurs at $Cr_{0\cdot81}Fe_{0\cdot19}$, with a γ value more than ten times that of chromium[3]. The fact that similarly high γ values were found also for specimens in the chromium–manganese alloy series at corresponding electron concentrations suggests that the observed effect may be related to characteristic values of the electron concentration. However, it is as yet uncertain whether or not the γ-peak should be interpreted simply in terms of density of states. The work on the low-temperature specific heat and on other physical properties of these alloys is continuing.

This work was supported by the U.S. Air Force under Contract No. 33 (616)-3789.

C. T. WEI
C. H. CHENG
P. A. BECK

College of Engineering,
University of Illinois,
Urbana.
Dec. 2.

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Effect of Low Concentrations of Alcohols on the Interfacial Tension between Water and Hydrocarbons

A STUDY has been made of the effect of low concentrations of *n*-aliphatic alcohols on the interfacial tension of water against hexane and octane. For this purpose an apparatus was designed, based on the drop-volume method, which allowed the interfacial tension to be measured with an accuracy of 0·04 dyne cm.$^{-1}$ in rigorously purified systems. Determinations were carried out at 10°, 25° and 40° C.

The results of the measurements are best presented graphically; for the system methanol – water – hexane they are shown in Fig. 1. The ordinates represent $\Delta\gamma$, the deviation of the interfacial tension from that of the hydrocarbon – pure water interface. The first addition of a trace of methanol (10^{-11} mol. l.$^{-1}$) causes, at the lower two temperatures, an elevation of the interfacial tension. $\Delta\gamma$, after reaching a peak at about 1·2 dyne cm.$^{-1}$ (about 30 times experimental error), levels off at approximately + 0·4 dyne cm.$^{-1}$, before becoming negative. At 40° C., these effects have vanished.

A similar behaviour has been observed in the case of ethanol and *n*-propanol, but the peak decreases in height and is shifted to higher alcohol concentrations as the number of carbon atoms in the alcohol increases. *n*-Butanol exhibits entirely 'normal' behaviour at all three temperatures.

The systematic nature of the results is emphasized by tabulating: (1) the maximum elevation of interfacial tension, and (2) the threshold concentrations above which normal, preferential adsorption of the solute occurs. This is done in Table 1.

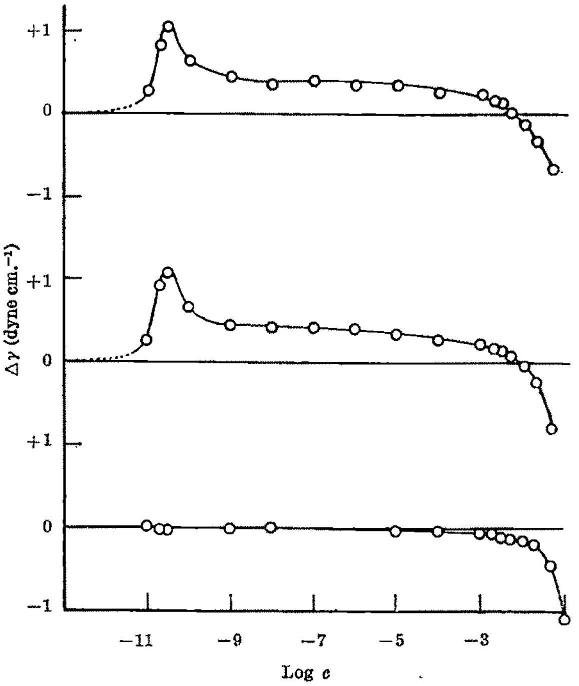

Fig. 1. Interfacial tension/concentration isotherms. Top, 10° C.; middle, 25° C.; bottom, 40° C.

When the thermodynamic functions associated with the generation of 1 cm.^{2} of interface, relative to those for the alcohol-free system, are calculated, it is found that the disappearance of the abnormalities between 25° and 40° C. is accompanied by an exaltation in ΔH, and an even more striking exaltation in $T\Delta S$. In order to ascertain whether the abnormalities disappear over a range of temperatures or at some definite temperature, interfacial tensions of several systems have been measured at temperatures between 25° and 40°. Similar measurements have also been made on the system hexane – pure water. In every case it is found that the abnormal behaviour disappears very suddenly between 33° and 37°. Even for the system hexane – water itself the slope of the interfacial tension/temperature curve exhibits a maximum in the same temperature-range. Fig. 2 shows the effect of temperature on the entropy (or relative entropy) of interface formation $\left(-\Delta S = \frac{d\gamma}{dT}\right)$. It is of interest to note that a similar type of curve is obtained for the entropy of surface formation of water, derived from the surface tension of water.

To show that the observed effects are not due to some peculiarity of the hydrocarbon normally used, determinations were carried out using *n*-octane as the oil phase. Identical results were obtained with this hydrocarbon. The abnormal effects are in all cases

Table 1

Alcohol	(1) Maximum $\Delta\gamma$ (dyne cm.$^{-1}$)		(2) Threshold concentration (mol. l.$^{-1}$)	
	10°	25°	10°	25°
MeOH	1·08	1·08	$6\cdot7 \times 10^{-3}$	$8\cdot5 \times 10^{-3}$
EtOH	0·70	0·72	$3\cdot0 \times 10^{-3}$	$4\cdot0 \times 10^{-3}$
PrOH	0·49	0·43	$0\cdot55 \times 10^{-3}$	$0\cdot3 \times 10^{-3}$

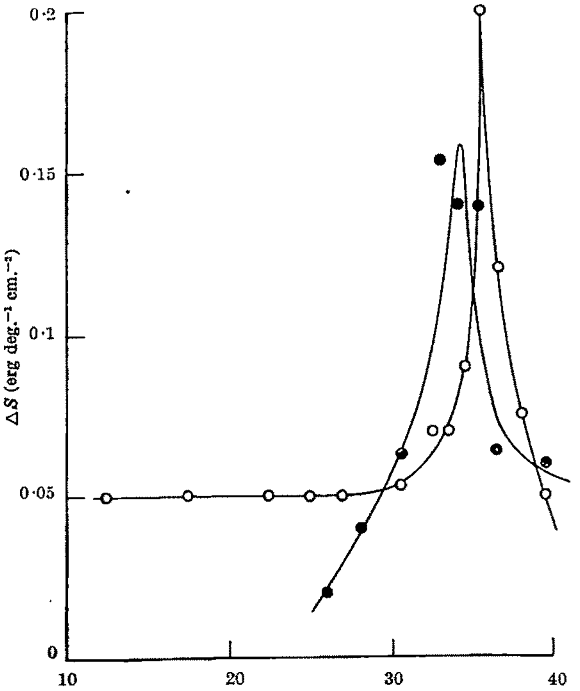

Fig. 2. Entropy of interface formation. ○, 6×10^{-5} *M* *n*-propanol/hexane (relative to water/hexane); ●, water hexane

abolished by the presence of hydrochloric acid in the aqueous phase.

A full account of the experiments carried out and a discussion of the abnormal effects obtained in terms of recent views on the structure of water and on the hydration of molecules will be published elsewhere.

F. Franks

Department of Chemistry,
Huddersfield College of Technology.

D. J. G. Ives

Department of Chemistry,
Birkbeck College,
London, W.C.1.
Nov. 27.

METEOROLOGY

Volcanoes as a Source of Atmospheric Ice Nuclei

In order to determine the nature and the concentration of ice-forming nuclei in the atmosphere, which are considered to play an important part in the initiation of rain, we have been carrying out, in Tokyo since April, measurements of the concentration of ice nuclei by means of an ice nuclei counter similar to that of Bigg[1]. The concentration is measured at temperatures of − 13° C., − 15° C. and − 20° C. It was found[2] that the concentration of ice nuclei was low in maritime air masses and high in the air masses which reached Japan from arid or semi-arid regions of the continent of Asia. Very high concentration in spring was found to be associated with the arrival of dust consisting of loess particles originating from the ground of the arid region of north China. The result of our experiment on loess particles which fell in Japan shows that they are effective as ice nuclei at temperatures below − 13° C. Despite the general tendency already mentioned, the concentration of ice nuclei in the atmosphere increased occasionally even in maritime air masses.

This phenomenon has been found to be related with eruptions of active volcanoes in Japan. In June and July 1957, Volcanoes Mihara, Aso, Suwanose and others were very active and erupted intermittently, ejecting ash high up into the atmosphere. The very high concentration observed during the period June 25–July 5 is considered to be due mainly to the ash from Volcano Mihara, which is at a distance of 100 km. to the south of Tokyo. The event which showed the most distinct and direct effect of volcanic ash was the eruption of Volcano Asama at 20h. 50m. on November 10, 1958. The eruption was the most violent among those in the past twenty years. After this eruption, Mt. Asama emitted coloured smoke (instead of white smoke as usually) continuously and erupted intermittently. The concentration of ice nuclei in the air observed in Tokyo is shown in Fig. 1, in which marked increase (40 times more than usual) in the nuclei concentration after the eruption is seen. The increase of concentration was large, but smaller than might have been expected from the scale of the eruption. It is considered to be due to a south-west wind, which carried most of the ash towards the north-east, while the measurement was made in Tokyo, which is situated to the south-east of the volcano. On November 12, the wind veered, smoke being observed to flow eastward and the concentration of nuclei increased. Minor peaks in the concentration seen in Fig. 1 were associated with the smaller eruptions which followed the violent one. The results of our laboratory experiments on volcanic materials from active volcanoes in Japan show that their property of serving as ice nuclei differs according to the nature of the material (Fig. 2) and that ash from Volcano Asama is very effective as previously described[3,4].

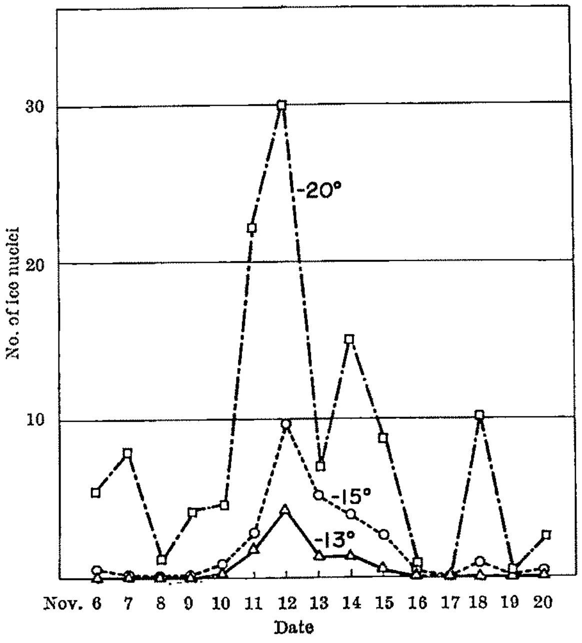

Fig. 1. Increase of the concentration of atmospheric ice nuclei due to eruptions of Volcano Asama. Measurement was made in Tokyo, 140 km. from the volcano. The greatest peak of the concentration corresponds to the most active period of eruptive activity

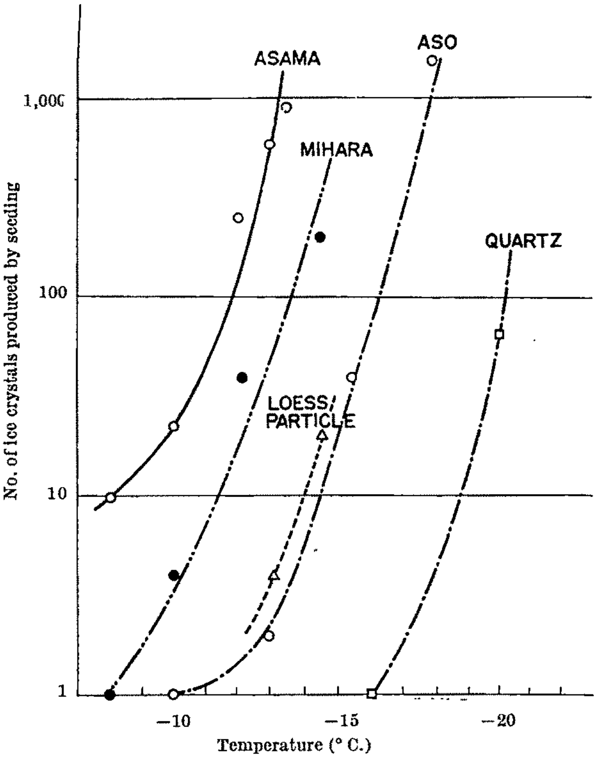

Fig. 2. Number of ice-crystals formed when 10 mgm. of each material is seeded into a cold box kept at the temperature indicated

Based on the statistical study of the relation between the amount of rainfall and the eruptions of Volcano Asama, we have suggested[3] that volcanic ash might be one of the important categories of ice nuclei in the atmosphere and play an important part in precipitation. The annual rainfall in the regions to which ash was carried by wind aloft was significantly high in the years in which the Volcano was active, and also the daily amount was significantly high on the days with eruption and the days following eruption.

The facts mentioned above strongly support the idea that some of the active volcanoes in the world are important sources of active ice nuclei, which may influence precipitation on a large scale. It may be suspected that the volcanic activity of the Earth might have played a part in the climatic change. A more detailed discussion of the subject will be published elsewhere.

K. Isono
M. Komabayasi
A. Ono

Geophysical Institute,
University of Tokyo. Dec. 1.

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Organic Nitrogen in New Zealand Snows

The nitrogen balance in New Zealand presents some rather interesting problems. In native forest and commercial exotic forests no natural source providing appreciable increments of nitrogen to the soils has yet been established. The non-symbiotic nitrogen-fixing bacteria *Clostridium butyricum* have been found in some tussock grassland soils by Ross[1]; but their numbers are thought to be too low to account for extensive fixation. Stevenson[2] has presented evidence that some of the higher plants may themselves fix quantities of nitrogen [see also *Nature*, January 24, p. 223]. The possibility that some nitrogen is supplied via the atmosphere has been investigated by me. Snow was collected above the vegetation line to avoid possibility of contamination by plant or animal debris. This was done in preference to the more conventional rain-water sampling, which is open to large contamination errors. Since the samples were collected in the early and mid-winter there is little possibility of contamination with pollen. The analyses of snow collected from various parts of New Zealand are shown in Table 1. The samples of snow were either kept frozen until analysis, or treated on collection with toluene to arrest any bacterial activity.

As can be seen from Table 1, New Zealand snow may contain up to 0·23 p.p.m. of bound nitrogen. No nitrogen is found as nitrate or nitrite, which are the classical nitrogen-cycle contributions from the atmosphere (products of electrical discharges). Perhaps the most interesting point in the above results is that sometimes most of the nitrogen is found in the 'albuminoid'[3] or organic nitrogen fraction.

Table 1

	Nitrogen content of snow samples (ref. 3)				
	NO_3^- (p.p.m.)	NO_2^- (p.p.m.)	NH_4^+ (p.p.m.)	Organic (albuminoid) (p.p.m.)	Total (p.p.m.)
(1) Sample of snow collected April 26, 1958, at 6,000 ft. (tree line 4,000 ft.) during snowstorm on Mt. Ruapehu (100 miles from sea). Wind W.-S.-W.	0	trace < 0·002	0·08	0·15	0·23
(2) Sample of freshly fallen snow collected April 26, 1958, at 5,300 ft. on Mt. Ruapehu	0	trace < 0·002	0·03	0·2	0·23
(3) Sample of snow collected May 3, 1958, at 6,000 ft. (tree line 4,000 ft.) on Mt. Egmont (20 miles from sea)	0	0	0·03	0·1	0·13
(4) Sample of snow collected April 27, 1958, at 7,000 ft. on Tasman Glacier (above tree line 4,000 ft., distance from sea, 25 miles)			0·1	0·12	0·22
(5) Sample of rain collected in Wellington in southerly storm on April 26, 1958. Distance up-wind to open sea, 10 miles; altitude, 10 ft.	0	0·002	0·27	0·2	0·47
(6) Sample of snow collected July 20, 1958, at 5,750 ft. (tree line 4,000 ft.) during a snowfall on Mt. Ruapehu (100 miles from sea). Wind, N.-W.	0	0	0·2	0·04	0·24
(7) Sample of snow collected July 21, 1958, at 6,575 ft. Same fall as in (6)	0	0	0·33	0·07	0·40
(8) Sample of snow collected July 21, 1958, at 8,070 ft. Same fall as in (6)	0	0	0·2	0·02	0·22
(9) Sample of snow collected August 2, 1958, at 6,000 ft. during snowstorm on Mt. Ruapehu	0	0·001	0·02	0·09	0·11

Albuminoid nitrogen is not usually measured by those who study atmospheric chemistry[4], and when measured has generally been attributed to contamination, though its significance is becoming realized[5]. Since the samples described in this communication were freshly collected snow from regions where no plants or animals exist, contamination from these sources should be negligible. No insoluble inorganic material was visible in the samples, so that cyclic terrestrial dust could not contribute appreciably to the nitrogen found in the samples. This is further supported by the lack of nitrate in the samples. The samples were collected in early winter and thus the pollen contribution would be negligible. Thus it seems that precipitation, at least in New Zealand, does in fact contain organic nitrogen which does not arise from contamination. From considerations of the geographical position of the sampling points with their lack of population and industry, I believe that the nitrogen found in the samples has its ultimate origin in the ocean and does represent a net transfer of nitrogen from ocean to land. This will be discussed in detail in a future communication.

If the results shown in Table 1 are taken as representative of the annual precipitation, it suggests that several pounds of nitrogen per acre are being deposited on New Zealand each year from the surrounding ocean. This might represent a contribution to the nitrogen economy of New Zealand soils.

I wish to thank Mr. H. J. Wood of the Dominion Laboratory, Wellington, for the analyses and Mr. A. J. Heine and Mr. G. Pallo, Department of Scientific and Industrial Research, for collecting samples.

A. T. Wilson

Division of Nuclear Sciences,
Private Bag, Lower Hutt,
New Zealand.

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CHEMISTRY

An Autoradiographic Method for distinguishing Samples labelled with Phosphorus-32 and Sulphur-35

Gillies[1] has recently described a method for examining insects labelled with sulphur-35 or phosphorus-32. The specimens were covered with two pieces of X-ray film, and autoradiographs made in the usual way. The low-energy sulphur β-particles (0·167 MeV.) were found to blacken only one film, while the high-energy phosphorus β-particles (1·71 MeV.) penetrated the first film and blackened the second also.

This useful method can be simplified by using film coated with photographic emulsion on both sides, as are most commercial X-ray films. In this laboratory, Kodak 'Kodirex' film is used for autoradiography of paper chromatograms, and with this material the two isotopes can be easily distinguished. If there is sufficient blackening of the film (such as is shown in the figure in Gillies's paper), a matt appearance is observed in reflected light and it can readily be seen whether one or both sides are affected. This can also be seen, even after much smaller exposures, by removing a little of the emulsion from both sides with a blunt scraper, either on the wet film after processing or after softening the gelatin on a dry film by moistening with 2 *N* sodium hydroxide. Examination of the film during photographic development is also helpful. Blackening of one side will not show on the other side of an uncleared film.

Gross over-exposure of a highly active sample should be avoided, since under these conditions even sulphur-35 will produce visible blackening on the second side of the film.

As would be expected, the effect of γ-rays is much smaller than that of β-particles on such a thin, light material as X-ray film. Thus bromine-82, with a β-particle energy of 0·44 MeV., produces a comparatively small amount of blackening on the second side of the film, although it is also a hard γ-emitter; more is produced by iodine-131, which has an average γ-energy less than that of bromine-82, but a higher β-energy (0·61 MeV. for 87 per cent of particles).

From the β-energies, using the equation given by Whitehouse and Putman[2], the half-thickness for various isotopes has been calculated, and thence the fraction of β-particles that would pass through 'Kodirex' film (which has a surface density of about 28 mgm./cm.^{2}). Approximate values of this factor for a number of useful isotopes are: carbon-14 and sulphur-35, virtually nil; bromine-82, 0·23; iodine-131, 0·40; phosphorus-32, 0·82. These figures are consistent with the relative blackening of the two sides of the film judged subjectively, and suggest that it might be feasible to distinguish more than two isotopes by this method.

W. G. Duncombe

The Wellcome Research Laboratories,
Langley Court,
Beckenham, Kent.

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A Chromatographic Technique for studying the Mechanism of Surface Catalysis

Gas chromatography has successfully been applied in the field of catalysis by Emmett and his co-workers[1-3], where it is referred to as a "microcatalytic chromatographic technique". This involves placing a small catalytic reactor directly on top of a gas chromatographic apparatus and injecting a small quantity of reactant at the top of the reactor. The slug of the reactant passes through the reactor, into the chromatographic column, and out through the analytical system; thus a rapid survey of the activity of a given catalyst can be carried out. This communication describes another new chromatographic technique for studying the mechanism of catalysis, measuring adsorption during reaction.

The importance of adsorption measurements during surface catalysis has previously been emphasized[4]. The adsorption on catalyst surface during reaction cannot be estimated from the separate adsorption data of each gas involved in the catalysis. The adsorption during reaction also depends upon the rate-controlling step of the overall reaction. Accordingly, if we could estimate the adsorption during catalysis, this should provide information on the rate-determining step of the reaction.

The adsorption measurements during surface catalysis can be carried out using the principle of gas chromatography in the following way. The gaseous reactant passes through the chromatographic column charged with catalyst as a carrier gas such that not all the reactant would be consumed while it passes through the column. The sample gas is injected at the top of the catalyst column. The slug of the sample gas then passes through the catalyst on which the reaction occurs, and out through the analytical system, being carried by the reactant. The more strongly the sample gas is adsorbed the longer becomes the time of its retention. Accordingly, the adsorbability of the sample gas during the reaction can be estimated.

The separate adsorption of each gas on the catalyst can be estimated independently in a similar way using inert carrier gas instead of reactant, and from the dependence on temperature of the apparent retention time its heat of adsorption can be determined.

Palladium was deposited on 'Celite 545' according to the method described by Sano[5] in the ratio 1 : 20. The catalyst was charged in the adsorption column 12 m. long. The apparent initial retention times with various carrier gases and samples at 99° C. are listed in Table 1, where the rate of flow of the carrier gases was 15 c.c./min. and the zero apparent initial retention time corresponded to 22·0 min. It was recognized with a detector tube method[6] that the formic acid partly remained unreacted while it passed through the catalyst column at 99° C. and a sharp peak of the acid slug was observed when it was injected as a sample.

Table 1

Carrier gases	Samples	Apparent initial retention time (min.)
Nitrogen	Argon	0
Nitrogen	Carbon dioxide	0
Nitrogen	Hydrogen	8·5
Hydrogen	Nitrogen	0
Hydrogen	Formic acid	0
Nitrogen saturated with formic acid at 20° C.	Carbon dioxide	0
	Hydrogen	8·0

The experimental results shown in Table 1 suggest that both carbon dioxide and formic acid could scarcely be adsorbed on the catalyst surface and only hydrogen could be adsorbed almost in adsorption equilibrium.

The reaction was also studied in a closed circulating system. It is shown by this experiment and also by Topley and Hinshelwood[7] that the decomposition of formic acid on palladium is first order in formic acid and slightly retarded by hydrogen, being independent of carbon dioxide pressure.

If the adsorption on the whole surface is assumed to be similar to that on the active part, it seems reasonable to suppose from all of these results that the rate-controlling step in the formic acid decomposition would be the chemisorption of the acid on to the catalyst surface. The chemisorption rate of the acid on the catalyst surface is proportional to the partial pressure of the acid, while the sites available for the chemisorption is decreased by the increasing hydrogen adsorption as hydrogen pressure becomes higher, thus showing the retardation by hydrogen.

The reason why the apparent initial retention time of hydrogen is shorter during the decomposition than with inert carrier gas is supposedly due to the hydrogen produced by the decomposition decreasing the apparent adsorbability to hydrogen.

It has been shown thus far that we can study adsorption during surface catalysis with the gas chromatographic technique. Another example to be treated with this new approach is to study the adsorption of decomposing (or polymerizing) reactant on the catalyst. Suppose a decomposition (or polymerization) reaction of *A*, and that *A* is weakly adsorbed on the catalyst almost in adsorption equilibrium and the surface reaction is rate-determining. Using similar apparatus to that mentioned above, and with an inert carrier gas, the reactant is injected at the top of the adsorption column filled with catalyst. From the retention time of the remaining reactant at various temperatures, its heat of adsorption would be estimated.

Generally speaking, it is difficult to estimate the heat of adsorption of a decomposing (or polymerizing) reactant except from the adsorption measurements during catalysis as has previously been reported in the decomposition of formic acid on a silver catalyst[8], as neither the calorimetric method nor the isosteric heat method can be applied, since decomposition takes place simultaneously. The new method, however, will enable us to determine such heats of adsorption.

This work was carried out with financial support from Ashai Chemical Industry Promoting Foundation, Inc., Tokyo, and also from the Ministry of Education, to which my thanks are due. The assistance of Mr. H. Miyake is gratefully acknowledged. I also wish to thank Dr. R. Amemiya for helpful discussions.

KENZI TAMARU

Department of Chemistry,
Yokohama National University,
Minami-ku, Yokohama.

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Polarography of Aromatic Hydrocarbons

HALF-WAVE potentials of aromatic hydrocarbons have been plotted graphically against calculated energies of the lowest unoccupied molecular orbitals, localization energies of one or two positions in the molecule and spectroscopic data[1–6]. Various linear relationships were discovered during these attempts to correlate reduction potential with some fundamental quantity related to molecular structure.

In his contribution[6] Given stated that those authors who compared half-wave potential with the localization energy of two positions in the molecule did not understand properly the polarographic evidence[4,7–11], which he believed to indicate that only one electron was added in the potential-determining stage of reduction.

While a two-electron reduction, which aromatic hydrocarbons undergo, may proceed perhaps in two one-electron stages a strong argument can be made that the potential-determining stage encompasses the addition of two electrons. In view of such an argument, which follows here, is it wise to discourage comparisons of half-wave potential with appropriate quantities related to two-electron addition ?

Inspection of the plots of E versus $\log_{10} i/(i_d - i)$ for the polarographic waves of aromatic hydrocarbons dissolved in a variety of solvent mixtures[4,7-11] shows that near linearity exists. The polarographic waves are therefore described by the Kolthoff–Lingane[12] empirical equation:

$$E = E_{1/2} - (2 \cdot 303\, RT/\alpha\, nF) \log_{10} i/(i_d - i) \quad (1)$$

where E is the cathode potential, $E_{1/2}$ the half-wave potential, R the gas constant, T the absolute temperature, F Faraday's constant, i the current, i_d the limiting current, n the number of electrons calculated directly from the magnitude of i_d and α a parameter. For the aromatic hydrocarbons $n = 2$ and α is usually less than 0·5.

In the example of the aromatic hydrocarbons, a possible reaction sequence for the aqueous polarographic reduction of the C═C bond is:

$$\mathrm{C{=}C} + 2e \overset{k_1}{\rightleftharpoons} \bar{\mathrm{C}}\mathrm{—}\bar{\mathrm{C}} \xrightarrow[\mathrm{H_2O}]{k} \mathrm{CH—}\bar{\mathrm{C}} \xrightarrow[\mathrm{H_2O}]{} \mathrm{CH—CH} \quad (2)$$

The rapid and irreversible conversion of the dianion into the saturated hydrocarbon removes the dianion from prolonged electrode equilibrium with the unsaturated hydrocarbon. (Such dianions are only stable in the absence of proton donors[13,14].) An equation (3) relevant to the sequence (2) may be derived using the methods described in ref. 15 for an electron uptake succeeded by a rapid reaction:

$$-E = (RT/\alpha\, nF) \log_e 1 \cdot 23\, D^{1/2} t^{-1/2} \mu^{-1} k^{-1} + (RT/\alpha\, nF) \log_e i/(i_d - i) \quad (3)$$

where D is the diffusion coefficient of the unsaturated hydrocarbon, t the drop time, μ the reaction layer thickness, k_1 the rate constant for electron uptake and α is interpreted now as the fraction of potential which assists the forward reaction.

Equation (3) is seen to be similar in form to equation (1) so far as the variables E, i, n and α are concerned. The term $(RT/\alpha\, nF) \log_e 1 \cdot 23\, D^{1/2} t^{-1/2} \mu^{-1} k^{-1}$ is constant for a given medium, temperature and drop time, and therefore may replace $E_{1/2}$ in equation (1). Complete verification awaits experimental determination of μ and k_1.

The similarity of equation (3) to the empirical equation for the polarographic waves of aromatic hydrocarbons (equation 1) shows that their polarographic reduction is described adequately by a mechanism the potential-determining stage of which is due to uptake of two electrons.

H. J. Gardner

Chemical Research Laboratories,
Commonwealth Scientific and
Industrial Research Organization,
Box 4331 G.P.O., Melbourne. Nov. 21.

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BIOCHEMISTRY and PHYSIOLOGY

An Electron Spin Resonance Study of the State of Copper in Fungal Laccase

The work of Keilin and Mann[1] and of Tissières[2] conclusively demonstrated that laccase is a copper-protein enzyme. By analogy with the suggestion of Kubowitz[3] in regard to polyphenoloxidase, it has generally been assumed that the enzyme contains Cu (II) in the resting state, and that catalytic activity is associated with a change in valency of the metal to Cu (I) (see, for example, ref. 4); but a direct study of this problem has never been made. Kertész[5] has recently pointed out that Kubowitz's indirect method may give erroneous results, and he has, in fact, presented evidence that the metal in mushroom polyphenoloxidase is always in the Cu (I) state. The recent development of the electron spin resonance technique has made possible a more direct approach to this problem, and in the present communication we would like to present results of this technique which clearly show that fungal laccase contains Cu (II) which, during the oxidation of substrate, changes valency to Cu (I).

The fungal laccase used for this investigation was obtained as an induced exoenzyme of *Polyporus versicolor*; it was purified by a procedure recently described[6]. On a protein basis, the purified enzyme contains 0·4 per cent copper[6]. It is deep blue in colour with an absorption maximum at 615 mμ. However, the crude enzyme is often green, in which cases pigment with an absorption maximum at 405 mμ can be removed by various methods, for example, chromatography on 'Dowex 2' or on calcium phosphate (R. Mosbach, unpublished experiments). No way has been found to dissociate the blue colour from the enzyme.

For the measurements of electron spin resonance, 0·2 ml. of an approximately 2 per cent laccase solution in deionized water (pH about 5) was used. The samples were contained in quartz tubes having inside and outside diameters of about 3 and 4·5 mm., respectively. Substrates and other substances tested were added as solids, and the solutions were quickly frozen in liquid air. No attempt was made to exclude oxygen from the solutions. The electron spin resonance spectra were recorded with the frozen solutions at approximately 100° K. with a 3-cm. Varian *V*-4500 spectrometer.

Typical electron spin resonance absorption curves under a number of experimental conditions are given in Fig. 1. The blank in Fig. 1*a* shows that the quartz tubes and solvent used are essentially free of contaminating copper, while the strong resonance line shown in Fig. 1*b* demonstrates that the enzyme contains Cu (II) in the resting state, since Cu (I) is not paramagnetic and, consequently, would give no electron spin resonance signal. The absorption curve is asymmetric, probably due to an anisotropic g-factor. The g-value at maximum absorption, which should be close to $g_\perp$, is $2 \cdot 06 \pm 0 \cdot 01$; other covalent Cu (II) complexes have been found to have similar g-values[7]. The small peaks to the left of the centre seem to be associated with the copper resonance, since they disappear on reduction (Fig. 1*c*), and they probably originate from an anisotropic hyperfine structure. It is hoped that a detailed study of simpler Cu (II) complexes (mainly with amino-acids and peptides) now in progress may yield information

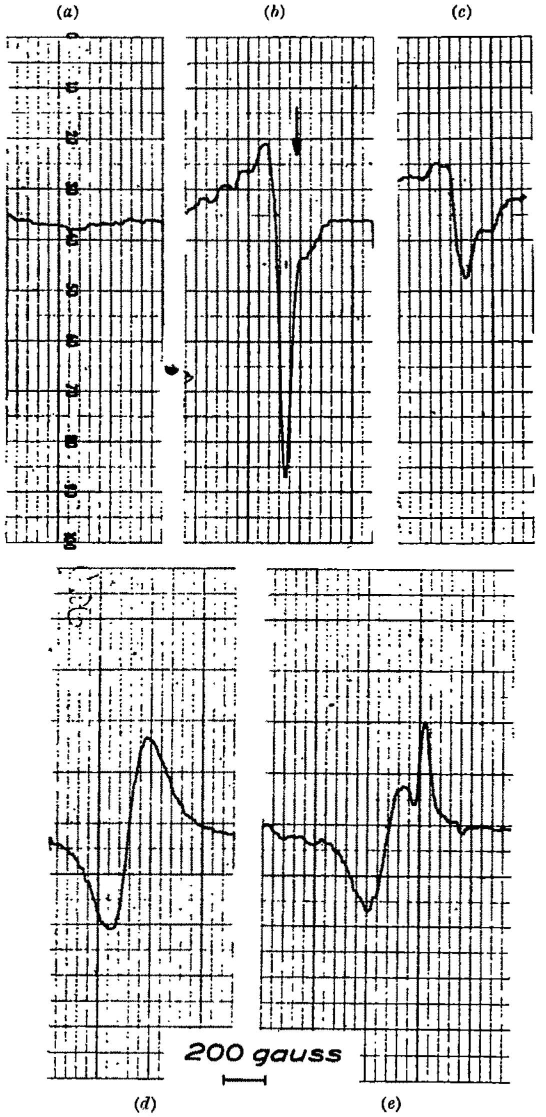

Fig. 1. Derivatives of electron spin resonance absorption curves recorded at about 100° K. Samples: (*a*) blank (deionized water); (*b*) about 2 per cent laccase solution; (*c*) about 2 per cent laccase solution plus excess catechol; (*d*) 1·5 × 10^{-3} *M* copper sulphate; (*e*) 1·5 × 10^{-3} *M* copper sulphate plus catechol. The arrow in (*b*) indicates the resonance field for free electrons

permitting a more exact interpretation of the laccase spectrum.

The absorption curve shown in Fig. 1*c* was recorded after a substrate (catechol) had been added to the enzyme solution used for Fig. 1*b*. The presence of substrate is seen greatly to diminish the electron spin resonance signal, showing that much of the metal has been reduced to Cu (I). Whether the remaining signal represents the steady-state concentration of oxidized enzyme, or is due to copper that is not associated with the activity of the enzyme, cannot be decided at present, since no experiments in the absence of oxygen have been performed. Other substrates, for example, ascorbic acid, cause a similar reduction in the resonance line, while, for example, tyrosine (a substrate of polyphenoloxidase) has no effect. When the substrate has been exhausted, the resonance reappears completely. It may be of interest to note that the blue colour disappears and reappears at the same time as the Cu (II) resonance line, though this does not necessarily mean that the colour is due to the metal ion (cf. refs. 8 and 9).

The spectra shown in Figs. 1*d* and 1*e* are included to demonstrate that the observed reduction in the resonance line cannot be due simply to complex formation with the substrate. Fig. 1*d* shows the absorption curve obtained with a solution of copper sulphate, and Fig. 1*e* that of the same solution after addition of catechol. It can be seen that, though the presence of substrate changes the shape of the absorption curve, it has no effect on the intensity of the signal.

The results reported here indicate that while Kubowitz's hypothesis[3] may not be valid for the enzyme for which it was formulated[5], it does appear to explain the role of the metal in laccase action. However, until more extensive experiments, in conjunction with kinetic measurements, have been performed, it is not possible unequivocally to relate the observed changes with the catalytic action of the enzyme. We hope to publish a more detailed report later.

This investigation has been supported by the Swedish Natural Science Research Council and the Rockefeller Foundation. We wish to thank Profs. A. Tiselius and K. Siegbahn for stimulating interest, and Dr. G. Fåhraeus for supplying the crude laccase from fungal cultures.

Bo G. Malmström
Rolf Mosbach
Tore Vänngård

Institutes of Biochemistry and Physics,
University of Uppsala. Nov. 7.

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Reaction of Sodium Borohydride with Wool

Recent developments[1-4] in the fractional extraction of wool proteins followed by their purification and physico-chemical characterization have led to a better understanding of the molecular structure of the fibre. But so far less than 50 per cent of the fibre has been separated into single proteins, and further work needs to be done in this field. A difficulty has been the lack of ideal methods for dissolving wool, for all those in current use suffer from one or more disadvantages, such as the side-reactions associated with the peracetic acid–ammonia procedure or the comparatively drastic conditions of *p*H and temperature often used with thioglycollate.

It has recently been found that sodium borohydride in alkaline solution rapidly dissolves wool under conditions of temperature and *p*H milder than many in current use. The reaction has been studied as follows: 1 gm. of solvent-scoured Merino wool was thoroughly wetted with 100 ml. of sodium borohydride solution, agitated at intervals and at the end of the reaction the residue filtered on to tared Whatman 54 filter paper, washed once with distilled water and dried at 105° C. to constant weight. The effects of

Table 1. EFFECT OF CONCENTRATION AND TEMPERATURE ON THE EXTRACTION OF WOOL PROTEIN BY SODIUM BOROHYDRIDE

Sodium borohydride concentration (*M*)	Urea concentration (*M*)	*p*H		Temperature (° C.)	Time (hr.)	Wool dissolved (per cent)
		Start	Finish			
0·1	0	11·0	10·6	40	1	89
1·0	0	11·0	10·6	1	12	60
1·0	0	10·2	10·3	1	12	71
1·0	0	11·0	10·6	20	1	92
1·0	6	10·9	10·6	1	12	87
1·0	6	10·9	10·6	20	1	91

variation in reagent composition and reaction temperature on the extent of wool solution are shown in Table 1.

The influence of *p*H on the reaction was next studied; but was difficult to measure because of the buffering effect of the metaborate end-product and the increase in the decomposition rate of the sodium borohydride as the *p*H was lowered. However, some experimental results (Table 2) with 1·0 *M* sodium borohydride solutions at 1·0° C. suggest that wool was dissolved optimally at initial *p*H values in the range 10–11.

Table 2. EFFECT OF INITIAL *p*H ON THE EXTRACTION OF WOOL PROTEIN BY SODIUM BOROHYDRIDE AT 1·0° C. FOR 12 HR.

Initial *p*H	Final *p*H	Wool dissolved (per cent)
9·1	10·5	35
10·2	10·3	71
11·0	10·5	52
11·8	11·5	7

The S-carboxymethyl derivative of the soluble protein was prepared by adjusting the *p*H of a digest solution (equivalent to 92 per cent of wool) to *p*H 8·5, a very slight excess over the theoretical amount of sodium iodoacetate was then added and the *p*H maintained at 8·5 for 15 min. The solution was then dialysed against running distilled water in a cellulose sausage casing with one end open to allow hydrogen to escape. The protein was then fractionated[2] on the basis of solubility at *p*H 4·5, the major part being insoluble under these conditions. Ultracentrifuge runs made on the *p*H 4·5 insoluble fraction, in 0·2 *M* potassium chloride at *p*H 7, showed the presence of at least 2 components (Fig. 1) of $S_{20\,w}$ 1·7 and 3·5 respectively, at a protein concentration of 1 per cent. Electrophoresis at *p*H 11 in 0·1 ionic strength buffer gave one spread-out peak in both boundaries.

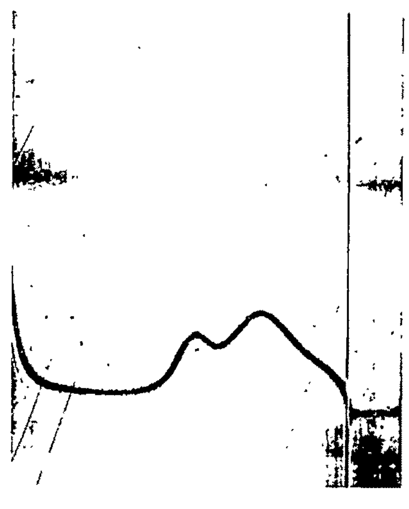

Fig. 1. Ultracentrifuge pattern of extracted wool protein (S-carboxymethyl derivative)

It is planned to study further the proteins in these extracts and in particular those more difficultly extractable materials which are largely undissolved by treatment of wool with alkaline thioglycollate solutions.

J. M. GILLESPIE*

Department of Biology,
Massachusetts Institute of Technology,
Cambridge, Mass.
Nov. 18.

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* Present address: Commonwealth Scientific and Industrial Research Organization, Division of Protein Chemistry, 343 Royal Parade, Parkville, Victoria, Australia.

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Preparation of Ceruloplasmin

CERULOPLASMIN is one of the minor components of plasma proteins. Most of the numerous publications which have appeared in the past several years are concerned with the evaluation and clinical significance of hypo- and hyper-ceruloplasminæmia. Nevertheless, the biological role of ceruloplasmin is still unknown.

Clinical and laboratory research might be facilitated if ceruloplasmin could be available in sufficient quantities.

Ceruloplasmin was first isolated by Holmberg and Laurell[1] using a technique based on the precipitation of globulins by 50 per cent saturation with ammonium sulphate and subsequent denaturation of the accompanying proteins by repeated treatment with a mixture of alcohol and chloroform.

As normal plasma contains but 150–300 mgm./l. of ceruloplasmin, it would be necessary to combine the preparation of suitable quantities of ceruloplasmin with one of the routine fractionation techniques.

The handling of Holmberg and Laurell's alcohol–chloroform mixture is rather inconvenient for the technical preparation of ceruloplasmin. So, we investigated other methods allowing the subfractionation of fractions containing ceruloplasmin.

Rivanol, an acridine derivative, has been used for preparing γ-globulin[2] and more recently for the isolation of β_1-metal-combining globulin[3]. Neither γ-globulin nor β_1-metal-combining protein is precipitated by rivanol, and these proteins are separated by alcohol precipitation of the supernatant. We think that rivanol might be used as a more general separating agent if it should be possible to dissociate the rivanol–protein complex without damaging the protein. Ceruloplasmin is particularly indicated for such a study as this protein exhibits oxidase activity allowing an easy control of each step of the separation technique.

Ceruloplasmin has a strong tendency to interact with other proteins, and under the conditions of our routine work we find the copper-protein in fraction III and IV. We have succeeded in isolating ceruloplasmin of both these fractions by subfractionation with rivanol. The method is based on the following principles: (1) Precipitation by rivanol of some accompanying globulins at *p*H 6. No oxidase activity should be detected in this precipitate. (2) Adjustment of *p*H to 7·8, and addition of another portion of diamino-ethoxyacridine-lactate in order to precipitate the fraction containing ceruloplasmin. Final *p*H should be 7·3–7·5. No oxidase activity should remain in the supernatant liquid. The latter might be used for preparing the β_1-metal-combining globulin in the case of fraction IV as starting material. (3) The rivanol–protein complex of step 2 is dissociated at *p*H 4; the accompanying proteins are eliminated by treatment with 50 per cent alcohol at *p*H 4·0. (4) The precipitate is extracted at *p*H 6. If further purification is necessary, it can be precipitated once more at *p*H 5·9, and 25 per cent alcohol concentration; it is then clarified before lyophilization.

M. STEINBUCH
M. QUENTIN
Centre National de Transfusion Sanguine,
Paris.
Oct. 31.

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Influence of Ions on the Uptake of Glucose and on the Effect of Insulin on it by Rat Diaphragm

INSULIN causes an increased uptake of glucose by the rat diaphragm *in vitro*[1]. The present communication reports the results of some experiments designed to study the influence of physiologically important cations on the uptake of glucose by the diaphragm of the rat in the presence and absence of insulin. Incidentally, the effects of the other related monovalent metallic ions and of changes in gas phase were also studied.

The incubation mixture consisted of a suitable buffer in isotonic sucrose or in a mixture of isotonic sucrose and isotonic solutions of the chlorides of certain mono- and di-valent metals. In every instance the *p*H of the medium was adjusted to 7·4 and glucose added to make a final concentration of about 250 mgm./100 ml. The buffers used, and their concentrations in the medium, were as follows: lithium, sodium and potassium bicarbonates, 0·02 *M*, disodium hydrogen phosphate, 0·01 *M*, *tris*aminomethane, 0·025 *M*. One hemidiaphragm was suspended in 1 ml. of the medium containing, where indicated, 100 milliunits of insulin per ml. The incubation was carried out at 38° C. for 90 min.

The results given in Table 1 show that diaphragm incubated in isotonic sucrose containing no metallic ion (*tris* buffer) or only small amounts of them (bicarbonate or phosphate buffer) removed glucose from the medium in amounts comparable to those removed from Gey and Gey's salt mixture. Insulin, however, had little or no effect on the uptake of glucose under such conditions. The ability of the tissue to respond to insulin appeared only when rather high concentrations of metallic ions such as sodium, potassium, rubidium, cæsium and magnesium were present in the medium. There was, however, little or no response to insulin in the presence of varying amounts of lithium or calcium.

The poorness of the response to insulin in media containing lithium ions apparently resulted from the high basal uptake of glucose from such media. On the other hand, the absence of any insulin response in the presence of calcium ions was possibly due to their toxic effects, as evidenced by the very low basal uptake of glucose in the presence of calcium ions. In both cases, the basal uptake of glucose could be adjusted to about the normal level by reducing the amounts of lithium or calcium ions added; but then again there was little or no response to insulin, presumably because the concentrations of the essential ions in the media were too low.

Table 1. EFFECT OF METALLIC IONS ON THE INFLUENCE OF INSULIN IN CAUSING INCREASED UPTAKE OF GLUCOSE BY RAT DIAPHRAGM UNDER AEROBIC CONDITION

Medium	Buffer	Glucose uptake (mgm./hr./gm. of tissue) Without insulin	With insulin (100 milliunits/ml.)	*P*
Gey and Gey's salt mixture	$NaHCO_3$	3·16±0·14	7·67±0·44*	<0·001
Sucrose	$NaHCO_3$	4·15±0·15	4·18±0·21	>0·05†
Sucrose	$KHCO_3$	4·11±0·28	4·64±0·26	<0·01
Sucrose	$LiHCO_3$	6·49±0·20	6·61±0·21	>0·05
Sucrose	Na_2HPO_4	4·58±0·19	4·87±0·15	>0·05
Sucrose	*Tris*	4·43±0·22	4·68±0·15	>0·05
Sucrose–NaCl (1 : 1)	$NaHCO_3$	5·16±0·28	8·04±0·40	<0·001
Sucrose–NaCl (1 : 1)	Na_2HPO_4	3·84±0·30	6·12±0·27	<0·001
Sucrose–NaCl (1 : 1)	*Tris*	4·46±0·12	7·18±0·06	<0·001
Sucrose–KCl (1 : 1)	$KHCO_3$	2·82±0·22	4·81±0·17	<0·01
Sucrose–KCl (3 : 1)	$KHCO_3$	2·99±0·25	5·59±0·18	<0·001
Sucrose—$MgCl_2$ (2 : 1)	*Tris*	3·84±0·13	5·79±0·39	<0·01
Sucrose–$CaCl_2$ (2 : 1)	*Tris*	0·61±0·13	0·71±0·08	>0·05
Sucrose–LiCl (1 : 1)	$LiHCO_3$	7·95±0·31	9·10±0·31	<0·01
Sucrose–LiCl (1 : 1)	*Tris*	6·80±0·24	7·93±0·40	<0·02
Sucrose–RbCl (2 : 1)	*Tris*	3·24±0·21	5·52±0·33	<0·001
Sucrose–CsCl (2 : 1)	*Tris*	3·30±0·13	6·33±0·37	<0·01

P = probability that the difference is due to chance.
* Standard error of the mean.
† Not significant.

It has already been noted that the basal uptake of glucose in the presence of lithium ions was high. In fact, the uptake differed in a regular way in the presence of equivalent amounts of the different metallic ions in the medium. A comparison of the uptake of glucose by the diaphragm in the presence of equivalent amounts of the monovalent metallic ions in the medium is given in Table 2. It is seen that the uptake followed the order of lithium > sodium > potassium = rubidium > cæsium. It is interesting to note that this is the order of the above ions in the so-called lyotropic or Hofmeister series.

The experiments so far reported were all carried out under aerobic condition. The results of a few similar experiments carried out under anaerobic condition are given in Table 3. The results show

Table 2. COMPARISON OF GLUCOSE UPTAKE BY RAT DIAPHRAGM INCUBATED IN MEDIA CONTAINING EQUIVALENT AMOUNTS OF THE MONOVALENT METALLIC IONS

Experiment No.	Composition of medium	Buffer	Glucose uptake	*P*
1	Sucrose–LiCl (1 : 1) Sucrose–NaCl (1 : 1)	Bicarbonate	7·48±0·26* 5·83±0·43	<0·05†
2	Sucrose–NaCl (1 : 1) Sucrose–KCl (1 : 1)	Bicarbonate	5·74±0·37 3·08±0·18	<0·01
3	Sucrose–LiCl (1 : 1) Sucrose–NaCl (1 : 1)	*Tris*	7·37±0·45 4·26±0·27	<0·001
4	Sucrose–NaCl (1 : 1) Sucrose–KCl (1 : 1)	*Tris*	4·14±0·27 2·55±0·21	<0·01
5	Sucrose–KCl (1 : 1) Sucrose–RbCl (1 : 1)	*Tris*	2·30±0·14 2·44±0·16	>0·05‡
6	Sucrose–KCl (1 : 1) Sucrose–CsCl (1 : 1)	*Tris*	2·05±0·16 1·56±0·10	<0·02

Experiments were done in pairs using hemidiaphragm from the same rat and comparing two of the metallic chlorides in turn under aerobic condition. *P* = probability that the difference is due to chance.
* Standard error of the mean.
† Significant.
‡ Not significant.

Table 3. INFLUENCE OF INSULIN ON GLUCOSE UPTAKE BY RAT DIAPHRAGM INCUBATED IN MIXTURES OF ISOTONIC SUCROSE AND ISOTONIC CHLORIDES OF SODIUM AND POTASSIUM UNDER ANAEROBIC CONDITION

Medium	Buffer	Glucose uptake (mgm./hr./gm. of tissue) Without insulin	With insulin (100 milli-units/ml.)	*P*
Sucrose–NaCl (1 : 1)	$NaHCO_3$	7·91 ± 0·22	8·39 ± 0·25*	>0·05†
Sucrose–NaCl (1 : 1)	Na_2HPO_4	3·32 ± 0·12	3·52 ± 0·12	>0·05
Sucrose–NaCl (1 : 1)	*Tris*	2·52 ± 0·09	2·81 ± 0·07	< 0·02
Sucrose–KCl (1 : 1)	$KHCO_3$	3·93 ± 0·25	4·40 ± 0·21	< 0·05‡

P = probability that the difference is due to chance.
* Standard error of the mean.
† Not significant.
‡ Significant.

that under anaerobiosis there was little response to insulin even when the medium contained the required ions in sufficient amounts. It may, however, be noted that with bicarbonate buffer the basal uptake of glucose tended to be higher under anaerobic conditions than under aerobic conditions. This was particularly true for sucrose–sodium chloride medium. These observations agree with those on the effect of anaerobiosis in increasing the basal uptake of glucose by rat diaphragm from Gey and Gey's salt mixture previously reported by Randle[2] from this laboratory.

From a consideration of the foregoing results one wonders whether there are two separate and distinct processes (one, insulin-independent and the other, insulin-dependent) involved in the uptake of glucose by the diaphragm of the rat. The process independent of insulin, although markedly influenced by strong ionic environments, can, nevertheless, function in a more or less normal way in the absence of metallic ions in the added medium. It can also function both under aerobic and anaerobic conditions. The process dependent on insulin, however, seems to operate best under aerobic condition and in the presence of rather high concentrations of certain metallic ions, including the physiologically important ions of sodium, potassium and magnesium. Ions of sodium and potassium are actually present in large amounts in the extracellular and intracellular fluids, respectively. The results reported here may thus have some physiological significance with respect to insulin action in the whole animal. They may also throw some light on the now generally accepted glucose-transport theory of insulin action[3].

The effect of the chloride ion, which was present in the medium in large amounts in most of the experiments reported here, has not been considered specifically. A general consideration of the results, however, indicates that most probably the chloride ion was not responsible for the effects of the added salts.

I am indebted to Prof. F. G. Young for advice and criticism and for the grant of laboratory facilities. My thanks are due to the managers of the I.C.I. Fellowships Fund, University of Cambridge, for the grant of a fellowship. The sample of crystalline insulin used in the above experiments was kindly given by Dr. C. G. Pope of the Wellcome Foundation, London.

GANGAGOBINDA BHATTACHARYA

Department of Biochemistry,
University of Cambridge.

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Immunochemically Active Cross-linked Polystyrene

THE communication of Gyenes, Rose and Sehon[1] prompts us to record briefly some observations in a closely related field.

For some time a group of our colleagues has been investigating the separation of antigens by means of their immunochemical specificity[2]. They have, for example, attempted to invert the method used by Campbell[3] and others for the fractionation of antibodies, and, by chemically conjugating antibody protein to a polymer such as cellulose, have used the resulting product in a column to separate antigens. The amount of antibody protein which can be incorporated in this manner is not large, and as a result of the generally unfavourable stoichiometry in respect to the antigen in the immune reaction, the capacity for the antigen is quite low. It occurred to us that greater capacity could be achieved if the antibody protein could be made an integral part of the three-dimensional structure, and we proceeded independently on lines precisely similar to those of Gyenes, Rose and Sehon.

'Distrene', an essentially linear polymer of styrene, was nitrated, initially with fuming nitric acid/sulphuric acid to give a product containing approximately 1 nitro group per styrene residue, and the product reduced with a large excess of stannous chloride to the polyamino compound[4]. This was soluble in dilute mineral acid but insoluble in dilute alkali. On diazotization in acid solution it gave, surprisingly, a very sparingly soluble diazonium salt. The γ-globulin fractions (which are rich in antibody) from several immune sera, prepared against a partially purified protein fraction from *Pasteurella pestis* (rabbit), against *B. anthracis* (horse) and an anti-ovalbumin serum (rabbit) were prepared by sodium sulphate precipitation[5]. The suspension of the polydiazonium styrene was then coupled with the immune γ-globulin in phosphate buffer at *p*H 8·5 and the excess unreacted diazonium groups rendered unreactive by coupling with resorcinol. The resulting cross-linked polymers were washed thoroughly with buffer until the filtrates were free from protein and were stored in isotonic saline. They contained 20–30 per cent of their weight of firmly bound protein. In view of the insolubility in water of the polydiazonium styrene, it was more closely examined and found to contain a small percentage of sulphonic acid groups, derived presumably from the sulphuric acid used in the nitrating process. When this was omitted, the product after reduction gave a completely soluble diazonium salt which would conjugate with much more γ-globulin. After treatment as above, the final polymer contained 60–70 per cent of its weight of protein. The products, though softer than the normal cross-linked polystyrene resins, are easily handled and readily filterable.

These 'resins' show approximately the capacity for absorbing their respective antigens that would be expected from the neutralizing capacity of the anti-sera from which they are prepared. They do this in all cases with a marked degree of specificity. In some cases the specificity is high. Thus, a 'resin' prepared from an anti-anthrax serum removed the protective antigen quantitatively from a culture filtrate prepared by the method of Thorne and Belton[6] without significant reduction in the total protein content of the filtrate. A 'resin' prepared from an anti-ovalbumin serum failed to remove bovine serum albumin from buffer solution but quantitatively removed ovalbumin under the same conditions: that from the plague anti-serum, though it removed the toxin quantitatively under all conditions tested, also removed some other protein. As several other antigens are present in the protein fraction used as antigen and the anti-serum contains antibodies to several constituents of the plague organism, this is not surprising.

The preparations were subject to a more stringent test for specificity by comparing their behaviour with precisely similar 'resins' prepared from normal γ-globulin. In the case of the anti-ovalbumin 'resin', the same high specificity was shown. Under the same conditions that the anti-ovalbumin 'resin' removed ovalbumin quantitatively from solution the resin prepared from normal rabbit γ-globulin removed none. The latter 'resin' did, however, remove some protein from the protein fraction from *P. pestis* and, despite a number of attempts, we have not succeeded in reducing this non-specific absorption below 15–25 per cent in this case.

We have also succeeded in preparing cross-linked resins by direct mercuration of polystyrene and cross-linking the polymer chains via the sulphydryl group of the antibody protein. Their immunochemical properties are exactly similar to those of the diazo 'resins'. Anthrax antigen absorbed on the anti-anthrax 'resin' when injected into rabbits and guinea pigs confers active immunity, and the animals will survive the challenge of a lethal dose of anthrax organisms. This indicates that the antigen retains its biological activity when absorbed.

Full details of this work will be published elsewhere.

We are indebted to Dr. D. A. L. Davies and Dr. A. P. MacLennan for toxicity tests in mice and to Mr. F. C. Belton for immunological assays of the anti-anthrax preparations.

L. H. Kent
J. H. R. Slade

Microbiological Research Establishment,
Ministry of Supply,
Porton, Nr. Salisbury, Wilts.
Nov. 24.

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Evidence for the Conversion of Quinic Acid to Shikimic Acid in Roses

The simultaneous occurrence of quinic and shikimic acids has been reported in several plants[1–3]. No definite role has been ascribed to either of these alicyclic acids in higher plants, except for participation of the former in the synthesis of chlorogenic acid[4].

In certain micro-organisms, shikimic acid has been demonstrated to be in the direct path to aromatic ring biosynthesis[5]. Microbial response to exogenous quinic acid has been reported in secondary mutants of *Aerobacter* which grew well when supplied with quinic acid[5]. Similar results have been reported for a mutant of *Neurospora*. A quinic dehydrogenase, which converts quinic acid to 5-dehydroquinic acid, has been demonstrated in *Aerobacter*[5], although the enzyme is not widely distributed. Davis[5] has concluded that quinic acid is not directly involved in aromatic ring biosynthesis in micro-organisms, and that where a requirement has been shown to exist, it is due to an adventitious quinic dehydrogenase.

The recent discovery of a high concentration of quinic acid in rose tissues[6] suggested the use of this plant for the biosynthesis of quinic acid labelled with carbon-14. This was accomplished by exposing actively growing plants of the variety 'Redbird' to $^{14}CO_2$ in light. Quinic acid labelled with carbon-14 was isolated by ion-exchange chromatography and crystallized. The labelled acid was fed into young blooms of 'Better Times' roses through cut stems and allowed to metabolize for 5, 23, 45 and 71 hr. before harvesting. The blooms were fractionated and radioactivity was determined in each of the non-volatile organic acids, free amino-acids, sugars and protein amino-acids.

More than 25 per cent of the carbon-14 in quinic acid fed to the roses could not be accounted for in any fraction and was presumably metabolized and lost as $^{14}CO_2$. This was confirmed in a subsequent experiment, where it was found that about 20 per cent of the radioactivity was evolved as $^{14}CO_2$ in 71 hr.

In petals, approximately 10 per cent of the incorporated carbon-14 could be accounted for in other compounds, and the remainder was present as quinic acid. About 25 per cent of the carbon-14 appearing in non-volatile organic acids was recovered as labelled shikimic acid. In petals of roses harvested after 71 hr., about 20 per cent of the carbon-14 in free amino-acids appeared in tyrosine and about 20 per cent appeared in phenylalanine.

The results show that quinic acid is metabolized by roses. This is borne out by other results indicating that quinic acid normally increases in concentration in rose blooms until they become about half open, after which the concentration decreases[7]. A similar development has been observed in apple fruits[2]. The evidence is clear that roses contain the enzymes necessary to reduce quinic to shikimic acid, although no evidence can be presented as to whether or not it follows the classical mechanism via quinic dehydrogenase, 5-dehydroquinase, and 5-dehydroshikimic reductase[5]. The possibility that the label in shikimic acid could arise from decarboxylation of quinic acid and its subsequent incorporation via a dark fixation mechanism has been ruled out since earlier experiments have shown no label to be incorporated into the quinic–shikimic fraction during dark fixation of $^{14}CO_2$.

A complete report of this work will be published in the *Contributions from Boyce Thompson Institute*.

L. H. Weinstein
C. A. Porter
H. J. Laurencot, jun.

Boyce Thompson Institute for
Plant Research, Inc.,
Yonkers, New York.
Nov. 20.

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Co-existence of the Embryonic (Third Normal) Hæmoglobin Fraction with Erythroblastosis in the Blood of Two Full-term New-born Babies with Multiple Malformations

In previous communications[1,2] the existence of a third normal, embryonic hæmoglobin was reported to be present in the blood of fœtuses up to five months of intra-uterine life. The hæmolysates of the blood of these fœtuses were characterized by their electrophoretic mobility on filter paper in a buffer solution of pH 8·6, which was slower than that shown by the hæmolysates obtained from the cord blood of full-term new-borns. The paper electrophoresis method did not permit us, however, to separate the different hæmoglobin fractions present either in the fœtal or in the embryonic blood.

By using the column chromatographic procedure described by Huisman and Prins[3], with some minor modifications, we were able to separate the three distinct fractions from the hæmolysate of a four month old embryo weighing 90 gm.

The hæmolysates of the cord blood of full-term new-born babies which were used at the same time as controls showed only two fractions (Fig. 1). The purpose of this communication is to report the finding of the third (embryonic) hæmoglobin fraction in the blood of two full-term new-born babies with multiple congenital malformations.

A further interesting and unusual feature of the blood of these new-borns was an erythroblastosis which was found in the blood film and which could not be explained by a blood group incompatibility between mothers and infants.

One baby weighing 2,560 gm. was born to a healthy 28-year-old primipara and showed the following congenital malformations: 1, multiple defects of the scalp; 2, hare lip; 3, polydactyly of both hands; 4, cryptorchism.

Mother and infant had identical blood groups (A CDe/CDe). No hepatosplenomegaly was found. In the blood film an unusually large number of nucleated red cells in all stages of maturation was found, but their absolute number was not determined. 1 hr. after birth the infant died. The hæmolysate of the cord blood of this malformed infant was found to contain 66·9 per cent of the alkali-resistant type of hæmoglobin. Paper electrophoresis did not reveal the presence of embryonic hæmoglobin, whereas the column chromatographic method, using an 'Amberlite *ICR* 50' column and a citrate buffer solution of pH 6·0 with a sodium ion concentration of 0·15 as an eluting solvent at a rate of flow of 9 ml. per hr., did reveal the three distinct hæmoglobin fractions similar to those shown in Fig. 1.

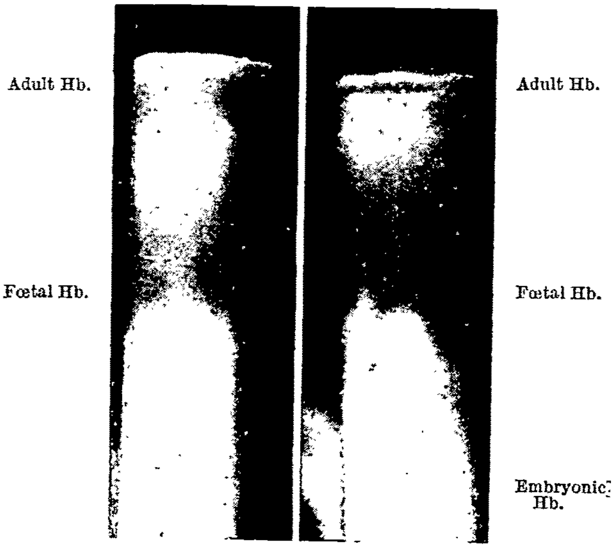

Fig. 1. 'Amberlite' column chromatography of (left) the hæmolysate of the cord blood of a full-term new-born showing two hæmoglobin fractions (adult and fœtal) and (right) of the hæmolysate of a four-months-old embryo showing three hæmoglobin fractions (adult, fœtal and embryonic)

Another baby was born to a healthy mother of two healthy children. The malformations of this child consisted of: 1, fusion of the two nasal fossa into one cavity; 2, under-development of the external genital organs of male type; 3, absence of the gonads in the very small scrotum and in both inguinal canals. The infant died shortly after birth, and section revealed the presence of a uterus and of two gonads, which on histological examination proved to be ovaries. The blood groups of both parents and of the child were identical (O cDe/cDe). The blood count of the baby's peripheral blood showed: hæmoglobin 18·2 gm./100 ml.; red blood count 6·4 millions/cu. mm.; white blood count 25,000/cu. mm. Examination of the blood film showed: nucleated erythrocytes, 45/100 white blood count. The direct and indirect Coombs tests were negative. The hæmolysate of the cord blood of this baby contained 73·3 per cent of the alkali-resistant hæmoglobin fraction, and column chromatographic examination revealed three distinct hæmoglobin fractions.

The use of the 'Amberlite' column chromatographic procedure represents an important step forward in the separation of the different fractions of normal hæmoglobin. Thus, we were able to separate not only the two hæmoglobin fractions known to be present in the cord blood of full-term new-borns, but also the third, embryonic, fraction (the lowest in the chromatographic column) in the blood of small embryos.

The interest of the present observation lies in the fact that by using the column chromatographic method we were, for the first time, able to discover the embryonic hæmoglobin fraction in the blood of two full-term new-borns who were severely malformed, whereas twenty other normal new-borns who served as controls did not show this fraction in their blood.

Another interesting fact lies in the co-existence of the embryonic hæmoglobin fraction with erythroblastosis in the blood of these malformed infants.

Erythroblastosis fœtalis has hitherto been found either associated with blood-group incompatibilities of the Rh and ABO systems or occasionally in the blood of prematures or of infants born to diabetic mothers. So far, we are unaware of reports on erythroblastosis in the blood of full-term new-borns with congenital malformations, in the absence of the above-mentioned conditions.

It is generally admitted that the synthesis of the normal, as well as of the abnormal, hæmoglobins is genetically determined, and so is the physiological process of replacement of the fœtal by the adult type of hæmoglobin which starts very early in embryonic life and continues until its completion between the sixth and the twenty-fourth month after birth.

It seems equally probable that the synthesis of the embryonic hæmoglobin as well as its replacement by the later (fœtal and adult) hæmoglobins are determined by genetic factors. The persistence of the embryonic hæmoglobin in the blood of the two above-described malformed new-borns could therefore be explained by a disturbance of one or more genetic factors which leads to the appearance of multiple developmental mutations, one of them being the persistence of embryonic hæmoglobin.

The association of persistent embryonic hæmoglobin with erythroblastosis in the blood of the new-borns is another phenomenon which remains to be explained by further investigations.

I. Halbrecht
Department of Obstetrics and Gynecology,
Hasharon Hospital,

Ch. Klibanski
F. Bar Ilan
Medical Research Center, Beilinson Hospital,
Petah Tikva, Israel. Nov. 5.

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Pharmacological Actions of γ-Butyrobetaine

γ-Butyrobetaine is a substance which has been known for many years to be present in the tissues of some cold-blooded animals, for example, snakes (*Python*)[1] and freshwater eels[2]. It appears, however, not to be present normally in mammalian tissues, but it has been located in muscle extract[3] and decaying horse flesh[4], and may appear in the urine in phosphorous poisoning[5] or in pernicious anæmia[6]. Linneweh[7] has shown that γ-butyrobetaine injected into dogs is largely excreted unchanged, although a small proportion is oxidized to carnitine.

Recently, Hosein[8] has shown that γ-butyrobetaine can be identified in the brains of mammals in which convulsions have been induced by the intraperitoneal injection of the so-called cerebral convulsants, while it is never found in this form in the brains of normal animals. Other studies by Hosein[8] have revealed that in normal animals γ-butyrobetaine occurs as a complex with coenzyme *A*. The pharmacological actions of γ-butyrobetaine, after subcutaneous administration into mice, were reported by Linneweh[7]. He found that there was increased respiration, profuse salivation and lacrymation, dilatation of the pupils, vasoconstriction, voiding of urine and fæces, block of motor nerve endings and cardiac arrest in diastole. A fatal dose of γ-butyrobetaine as the chloride was 70–80 mgm. in a 15-gm. mouse. From these observations Linneweh concluded that γ-butyrobetaine behaved as a curare-like substance.

In the light of Hosein's findings, we have felt it desirable to investigate again some of the pharmacological actions of this substance. γ-Butyrobetaine was prepared synthetically as the free base and used for all tests. Subcutaneous injection of as little as 1 mgm. was found to be fatal to a 25-gm. mouse, and the sequence of events described by Linneweh[7] was invariably observed. There is evidently a profound autonomic excitation which culminates in death apparently due to cardiac failure.

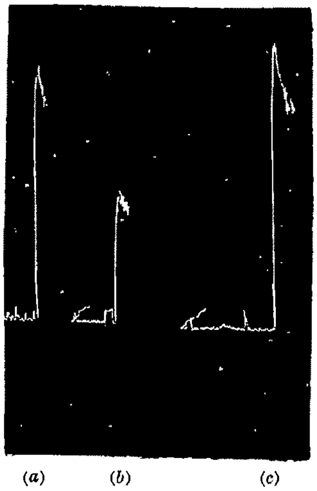

Fig. 1. The effect of acetylcholine and factor I on the isolated ileum of the guinea pig. (*a*) Acetylcholine, 1·2 × 10^{-9}; (*b*) acetylcholine, 1·2 × 10^{-9} + factor I, 0·003 units/ml. of bath fluid; (*c*) acetylcholine, 1·2 × 10^{-9}

In its actions γ-butyrobetaine resembles those of acetylcholine except that it is much less active on a weight-for-weight basis and its action is considerably prolonged. It seems not to be enzymatically destroyed in the body at any appreciable rate, as Linneweh's experiments on its recovery from urine showed. We have observed a parallelism in action between γ-butyrobetaine and acetylcholine for depression of the blood pressure of the cat, stimulation of the perfused superior cervical ganglion in the cat, and inhibition of the isolated perfused frog heart. Inhibition of mammalian neuromuscular transmission, similar to that caused by large doses of acetylcholine[9], is invariably found.

In only one preparation has it been possible to show a qualitative difference in action between γ-butyrobetaine and acetylcholine. The isolated ileum of the guinea pig is induced to contract by the addition of γ-butyrobetaine to the bath. There is an initial quick response, resembling that caused by acetylcholine, which is sometimes followed by a slow tonic contraction which may continue for several minutes. In addition, the following difference can be observed. The contractions of the intestine induced by acetylcholine are reduced or abolished by the addition to the bath of a brain extract containing

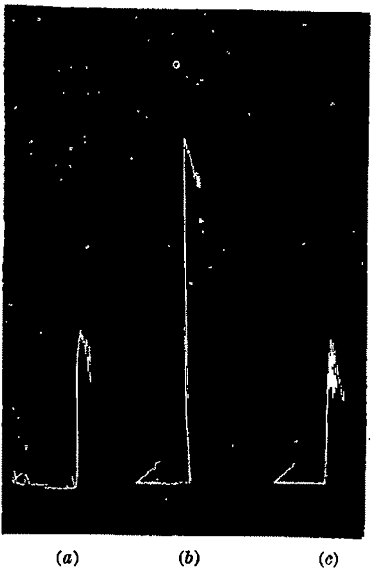

Fig. 2. The effect of γ-butyrobetaine and factor I on the isolated ileum of the guinea pig. (*a*) γ-Butyrobetaine, 5 × 10^{-8}; (*b*) γ-butyrobetaine, 5 × 10^{-8} + factor I, 0·003 units/ml. of bath fluid; (*c*) γ-butyrobetaine, 5 × 10^{-8}

an inhibitory principle (factor I)[10]. This effect is shown in Fig. 1. However, when γ-butyrobetaine and factor I are added together to the intestine bath, there is an enhancement of the contraction (Fig. 2). No evidence of an inhibitory effect of factor I on the contractions induced by γ-butyrobetaine similar to that observed with acetylcholine has ever been found. In those cases where a slow tonic contraction of the tissue succeeds the quick response, it appears that the potentiation due to factor I is confined to the fast phase[10].

Thus, although the parallelism in action between γ-butyrobetaine and acetylcholine is close, it is not entirely general. Since the relationship between acetylcholine and factor I on the ileum of the guinea pig is not entirely clear, it is not possible to comment on the difference here observed with γ-butyrobetaine. The other pharmacological actions of γ-butyrobetaine can be satisfactorily explained by a prolonged action like that of acetylcholine.

E. A. HOSEIN

Department of Biochemistry,
McGill University, Montreal.

H. MCLENNAN

Department of Physiology,
University of British Columbia,
Vancouver.

Nov. 12.

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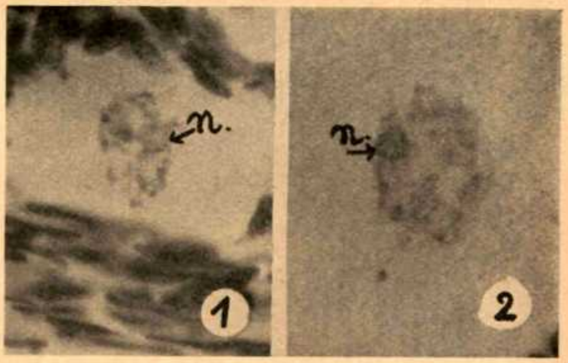
Content of Deoxyribonucleic Acid of the Germinal Vesicle of the Primary Oocyte in the Rabbit

BY means of centrifugation experiments, evidence of persistence of deoxyribonucleic acid in the growing nucleus of the primary oocyte was put forward by J. Brachet[1]. J. Govaert[2] was able to demonstrate that, in *Fasciola hepatica*, the acid not only persists but also remains quantitatively constant in the germinal vesicle. The same quantitative constancy was later found by J. Mulnard[3] to be existing in the oocytes of *Acanthoscelides obtectus*.

During our studies on content of deoxyribonucleic acid in the ovary of the rabbit, we tried to discover if this same constancy also occurs in this mammalian species. In the rabbit ovary, fixed in alcohol (75 parts), formalin (20 parts) and acetic acid (5 parts), the Feulgen reaction shows more or less visible chromosomal loops in the germinal vesicles of the oocytes, present in primary follicles (Figs. 1 and 2). This distribution, although not favourable, permits measurements by means of L. Lison's histophotometrical method[4], so that a relative amount of deoxyribonucleic acid, expressed in arbitrary units, can be obtained and compared with a standard value, given by the mean acid content of spermatocytes I measured in a rabbit testis under identical experimental conditions. The mean content of deoxyribonucleic acid for 107 measured oocytes was 2,400 ± 50·2 ($S = 523{\cdot}7$), while for 301 spermatocytes I we obtained 2,393 ± 26·8 ($S = 465{\cdot}4$).



Figs. 1 and 2. Demonstration of the youngest (1) and oldest (2) measured germinal vesicles, stained by the Feulgen reaction. Statistical computation shows that, so far as their content of deoxyribonucleic acid is concerned, the nuclei between those two limits belong to the same population (*n*, nucleolus, surrounded by a ring of nucleolus-associated chromatin)

The distribution of deoxyribonucleic acid found in those young germinal vesicles seemed to permit only the demonstration of an order of magnitude.

These results suggest that in the rabbit oocyte I, the content of deoxyribonucleic acid corresponds to the theoretically expected content (4*n*, as in the spermatocytes I). Moreover, this content remains unchanged at least during the formation of the young germinal vesicle, up to the stage measured here.

This research was supported by a grant of the Belgian F.N.R.S.

D. VAN DE KERCKHOVE

Department of Normal and Comparative Anatomy,
Belgian Centre of Normal and Pathological Growth,
University of Ghent.

Nov. 13.

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Liver Hexokinase Activity in Rats adapted to Intermittent Starvation

FÁBRY'S experiments[1] which were performed in this laboratory have shown that, in rats adapted to intermittent starvation, more glycogen is deposited in the liver after the intake of an equal amount of a mixed diet than in rats fed normally. We may thus expect that in these animals there develops an adaptation of the enzymes participating in glycogen synthesis. We have therefore attempted to estimate the liver hexokinase activity, because this enzyme has a key position in the synthesis of glycogen.

We used female Wistar rats with an initial weight of about 100 gm. During the experiment the animals were kept at a temperature of 21–23° C. During the six-week period of adaptation to intermittent starvation we interposed gradually longer fasts between the days when the animals had free access to food. During the last week of adaptation the animals were fed only twice[1]. The total food consumption in the adapted animals amounted to 60 per cent of the intake of control animals fed *ad lib.* Throughout the experimental period the animals had free access to water. The rats were fed on a stock diet (Larsen's diet) providing about 25 cal. per cent protein, 25 cal. per cent fat and 50 cal. per cent carbohydrate.

Table 1. HEXOKINASE ACTIVITY OF LIVER HOMOGENATE OF RATS ADAPTED TO INTERMITTENT STARVATION

Experimental group	No. of rats	Glucose utilized ($\gamma \pm$ S.E.)	P	Initial glycogen content ($\gamma \pm$ S.E.)	Uptake of glycogen ($\gamma \pm$ S.E.)
A. Stock diet					
Fed animals: adapted	8	25·5 ± 8·1	< 0·05	256 ± 78	75 ± 19·5
controls	6	2·9 ± 8·5		215 ± 62	55 ± 13·5
Fasted for 24 hr.: adapted	8	30·0 ± 6·0	< 0·02	34 ± 5·1	28·9 ± 7·0
controls	7	10·5 ± 6·2		23 ± 3·8	20·0 ± 3·6
Fasted for 48 hr.: adapted	7	27·0 ± 3·7	< 0·01	32·5 ± 3·9	31·6 ± 2·1
controls	6	8·5 ± 3·0		26·6 ± 6·5	23·2 ± 5·7
B. Carbohydrate-free diet					
Fasted for 24 hr.: adapted	6	10·5 ± 3·5	N.S.	21·2 ± 2·7	14·5 ± 3·2
controls	6	9·5 ± 4·4		24·2 ± 5·3	19·5 ± 3·4

The amount of homogenate used corresponded to 20 mgm. liver (wet weight). 150γ glucose was added.

Hexokinase activity was estimated in the liver homogenate, using Long's method[2] based on the disappearance of added glucose. Simultaneously, we investigated the glycogen content at the beginning and at the end of a period of incubation in trichloracetic deproteinate, using Nelson's method[3]. Because the nitrogen content of the liver, calculated on a wet-weight basis, is practically the same in animals adapted to intermittent starvation and in control animals[4], we evaluated the results on a wet-weight basis.

Enzyme activity was assessed in animals fed 10 gm. of Larsen's diet per 100 gm. body-weight (the food was consumed freely overnight) and after a 24- and a 48-hr. fast respectively. Before fasting, the rats received a weighed quantity of Larsen's diet (10 gm./100 gm. body-weight).

As can be seen from Table 1, rats adapted to intermittent starvation have a markedly increased hexokinase activity, both when satiated and while fasting, compared with normally fed controls. The uptake of added glucose, which is used as the criterion of hexokinase activity, was on average 20 per cent in these animals, while in rats fed normally it was considerably lower, even approaching zero. The small uptake of glucose in the liver homogenate of normal rats has already been recorded[2,5].

The relatively high content of glycogen in this tissue and the glycogenolysis during incubation obviously play a part in this phenomenon. In animals adapted to intermittent starvation, the glycogen content of the liver homogenate is equal to or somewhat higher than in the controls; the glycogenolysis during incubation could thus only diminish the difference between the adapted animals and controls, and have an adverse effect on our results.

In animals adapted to intermittent starvation, a marked hyperphagia develops when they have access to food[6] and the intestinal absorption of glucose is increased[7]. It is therefore possible that the increased activity of liver hexokinase was induced by the intermittently increased supply of glucose by the portal blood to the liver. We therefore adapted a further group of animals to intermittent starvation, using the same method. The Larsen stock diet was, however, replaced by a diet practically free of carbohydrate (69·9 cal. per cent protein, 29·75 cal. per cent fat and 0·75 cal. per cent carbohydrate). Despite the fact that in adapted animals even under these conditions hyperphagia developed when the animals were allowed food, we found no difference in the hexokinase activity of adapted and control animals fed *ad lib.* on the same diet after a 24-hr. fast (Table 1*B*). We can thus assume that the deciding factor for the increase of liver hexokinase, revealed in the intermittently starving animals on a mixed diet, was the intermittently increased supply of glucose absorbed by the liver during the periods of free access to food. We thus may speak of a "substrate-induced enzymatic adaptation"[8].

R. PETRÁSEK

Physiological Department,
Institute of Human Nutrition,
Budějovická 800,
Prague 14.
Oct. 16.

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Granulocyte Precipitins of Human Tissues and Activated Sera

IN a preliminary communication[1] we reported that the addition of water-soluble extracts of human granulocytes to saline extracts of any other human cell resulted in the formation of a precipitate. This phenomenon can be studied by Ouchterlony's double gel diffusion method[2]. The substances giving rise to the precipitate were designated as 'granulocyte factor' and 'tissue factor'.

In the present communication it will be shown that the tissue factor exists in most human sera, including those from apparently normal subjects, but in an inactive form. Activation of this substance can be accomplished by dialysis of the sera against physiological saline.

The methods used to prepare extracts from granulocytes and other leucocytes will be presented in detail elsewhere. Human granulocytes were isolated from heparinized blood of patients with chronic myelogenous leukæmia using polyvinylpyrrolidone according to Wasastjerna's procedure[3], modified to handle large amounts of blood. Contaminating erythrocytes were removed by the addition of hypotonic saline, which lysed the red cells but not the leucocytes. The thoroughly washed cells were homogenized in ice-cold saline in a Waring blendor, and the supernate was dialysed against distilled water. After removal of the precipitate, the water-soluble fraction was lyophilized. Extracts of normal leukocytes and white cells from other forms of leukæmia were obtained in a similar manner.

The double gel diffusion method has been described[4]. All cups were filled simultaneously with 0·2 ml. of the reagents and refilled the next day with the same amount. When the extracts were used at optimal concentration, lines of precipitate could be observed within 24 hr. From Fig. 1 it can be seen that the

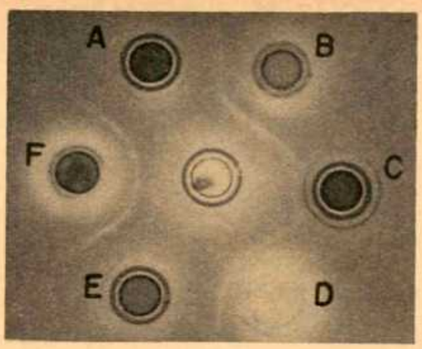

Fig. 1. Centre cup and cups *A* and *E*, extracts from granulocytes of three different patients with chronic myelogenous leukæmia. Cups *B* and *F*, extracts of leucocytes from two patients with acute leukæmia. Cup *D*, extract of leucocytes from a patient with chronic lymphocytic leukæmia. Cup *C* is empty

extracts of granulocytes did not react with each other, but that lines of precipitate were formed between the extracts of granulocytes and other leucocytes. These lines simulated immune systems in that they were dissolved if the initial concentration of one of the reagents was in excess, and they migrated away from the cup containing this reagent. The reaction is specific in that only extracts from normal or leukæmic granulocytes react with the other cell extracts. It resembles in this respect the system described by Seligmann *et al.*[5]. The tissue factor has been demonstrated in all human cells examined, including those grown in tissue culture or on the allantoic membrane of the chick embryo, indicating that it is not a serum contaminant.

No reactions were observed between extracts of granulocytes and untreated human sera. However, after dialysis against saline, most of these sera reacted in the same manner as did extracts from cells containing the tissue factor (Fig. 2). When activated sera were placed adjacent to a cup containing tissue extract, the two resulting lines of precipitate coalesced, indicating that the precipitin of the serum was the same as that of the tissues.

The fact that most human sera could be activated by dialysis suggests that they contain a substance of low molecular weight capable of inhibiting the reaction between serum tissue factor and the granulocyte factor. It is not known whether the tissue factor has a physiological function, but the presence of an inhibitor against it indicates that it may. At present we are trying to isolate and define the two precipitating factors as well as their inhibitor. This system is now also being studied in pathological sera.

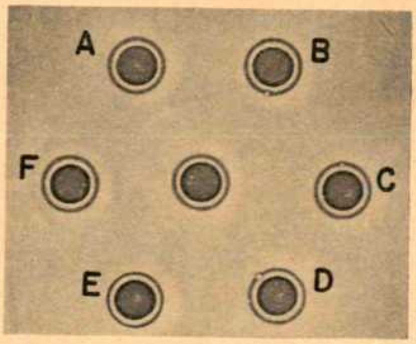

Fig. 2. Centre cup, extract of granulocytes; Cups *A*, *C* and *E*, dialysed sera (1 : 2). Cups *B*, *D* and *F*, the same sera before dialysis

We wish to thank Mr. Rudolph Smith for his technical assistance.

This investigation was supported by a research grant (*C*-2359 *M* and *I*) from the National Cancer Institute of the National Institute of Health, Bethesda, Maryland.

LEONHARD KORNGOLD
GERDA VAN LEEUWEN
DANIEL G. MILLER

Division of Experimental Pathology,
Sloan-Kettering Institute for Cancer Research,
and the Sloan-Kettering Division,
Cornell University Medical College,
New York.

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Comparison of the Formation of the Complex, Sensitized Erythrocyte-Complement ($EAC'_{1,4,2}$) in Hæmolytic Systems differing in their Hæmolysin and Complement-fixing Activities

IN a recent study[1] we compared the complement fixing and hæmolytic titres of several different hæmolytic systems. We found a lack of correlation between the titres of these two activities when compared in different hæmolytic systems. In addition, we found striking differences in the quantity of complement (C') capable of being fixed by these systems. These findings indicated that C' fixation and hæmolysis represent quantitatively distinct serological properties.

The sequence of action of the C' components has been determined by Mayer and co-workers[2] for the sensitized sheep cell. The demonstration of this sequence, as well as current work[3,4] concerned with the participation of the C' components in immune hæmolysis, involves the fixation of measurable amounts of the C' components by sensitized cells (*EA*). In view of our findings we thought it would be of interest to compare the fixation of the C' components in hæmolytic systems which differ markedly in their C'-fixing activities.

As illustrated by Mayer *et al.*[2], in the Forssman antibody and sheep cell system, $EAC'_{1,4,2}$ formation may proceed at 0° C. without undergoing appreciable lysis. They have further shown that the presence of ethylenediamine tetraacetic acid prevents formation of the $EAC'_{1,4,2}$ complex by binding calcium and magnesium ions which are necessary for the formation of this complex. Employing this information, we examined the extent of $EAC'_{1,4,2}$ formation in three different hæmolytic systems according to the following procedure.

1 ml. of a serial two-fold dilution of each antiserum was placed in two series of tubes in an ice-bath. 1 ml. of a 1 : 10 dilution of whole guinea pig C' and 1·0 ml. of the standardized cell suspension were added. The tubes were incubated for 4 hr. at 0° C. with frequent mixing. Then 1·0-ml. amounts of 0·05 *M* ethylenediamine tetraacetic acid was added to one of each series of tubes to give a final concentration of 0·01 *M* in a total reaction volume of 5·0 ml. All tubes were then incubated for 30 min. at 37° C., centrifuged and the amount of lysis was determined by examining the supernatants spectro-

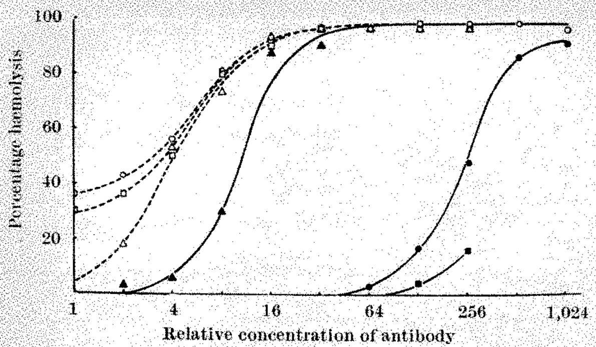

Fig. 1. The comparison of $EAC'_{1,4,2}$ formation in three hæmolytic systems. Circles, rabbit anti-sheep and sheep cells; squares, human anti-A and sheep cells; triangles, rabbit anti-human O and O cells. Open symbols, in the absence of ethylenediamine tetraacetic acid; solid symbols, in the presence of ethylenediamine tetraacetic acid

photometrically. Included were appropriate controls for: spontaneous lysis, the extent of lysis occurring during incubation at 0° C., and the effectiveness of $C'_{1,4,2}$ fixation inhibition by ethylenediamine tetraacetic acid.

The results are presented in Fig. 1 as a plot of per cent lysis versus relative antibody concentration. Antibody concentrations were examined in each system which gave approximately the same amount of lysis in the absence of ethylenediamine tetraacetic acid. This was done so that with ethylenediamine tetraacetic acid added, the relative amounts of antibody required for lysis in each system could be directly compared. It can be seen that, although the relative amounts of antibody in each system gave equivalent lysis in the absence of ethylenediamine tetraacetic acid, the relative amounts of antibody required for lysis in the presence of ethylenediamine tetraacetic acid were strikingly different for each system. Twice the concentration of antibody was required in the rabbit anti-human system for sufficient $EAC'_{1,4,2}$ complex formation at 0° C. to obtain lysis equivalent to that which was obtained in the absence of ethylenediamine tetraacetic acid. The rabbit anti-sheep and human anti-A serums with sheep cells required approximately 60 and 95 times respectively the amount of antibody to obtain equivalent lysis in the presence of ethylenediamine tetraacetic acid. These findings correspond well with the ratios of the hæmolysin and C'-fixing titres previously obtained for these systems[1].

These results illustrate differences in the ability of these hæmolytic systems to form the $EAC'_{1,4,2}$ complex at 0° C., as judged by the relative amounts of antibody required for lysis with the addition of ethylenediamine tetraacetic acid. These results further show that the hæmolysin titres in the presence of ethylenediamine tetraacetic acid are unrelated to the hæmolysin titre in the absence of ethylenediamine tetraacetic acid. However, the hæmolysin titres in the presence of ethylenediamine tetraacetic acid do show a relationship to the C'-fixing activities of these systems.

HAROLD S. GOODMAN
Mount Sinai Medical Research Foundation,
Chicago.

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Effect of Cross-linking by Formaldehyde on the Contraction–Relaxation of Rat Tail Tendon

RECENTLY, Banga *et al.*[1] demonstrated that tendons of the tail of a rat spontaneously shortened and relaxed when they were placed in 40 per cent potassium iodide at room temperature. Aging influenced the length–time curves so that rapid contraction was followed by rapid relaxation in the young but slow relaxation in the old. Cross-linking in collagen has been a widely discussed concept of the effect of the aging process. If the development of more highly polymerized collagen is the effect of aging then tanning young tendons with formaldehyde, a cross-linking reaction, should 'age' them a certain amount. The following experiments were done to test this hypothesis.

Tendons of the tail of a rat, having mass/length ratios of 0·3–0·4 mgm./cm., were treated for 15 min. by exposing them to various dilutions of 37 per cent formalin in sodium acetate solutions buffered at *p*H 7·8. Following treatment, 6-cm. lengths were clamped inside a glass cylinder where the bottom end of the fibre was fixed and the top was free to actuate the direct writing arm of an electrically driven kymograph. A mechanical magnification of × 5 was obtained for the curvilinear co-ordinate system. Plots were made in rectilinear co-ordinates of length as a function of time for each tendon studied. The net force on the tendon was estimated at between 1 and 2 gm. but was constant throughout the study. Chemical contraction was induced at 23° C. by using freshly prepared aqueous 40 per cent potassium iodide, which was added rapidly to the tube containing the fibre.

Fig. 1 shows that the length–time curves depend upon the concentration of formaldehyde used for cross-linking collagen in the tendons. At 1/1,000 dilution, the fibres contracted 65 per cent of their length in less than 10 min. and remained so for at least 50 min. At 1/100,000 dilution there was a 40 per cent decrease in length in less than 5 min. which returned to the original length 40 min. later. These measurements were repeated using 0·5 *M* acetic acid instead of 40 per cent potassium iodide, and the same response was obtained to formaldehyde treatment.

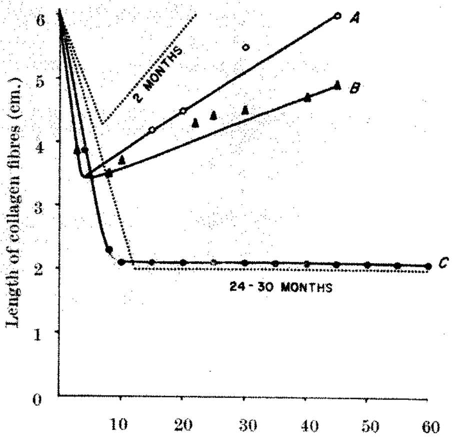

Fig. 1. The contraction–relaxation of tendons of the rat tail induced by 40 per cent potassium iodide as a function of degree of cross-linking by formaldehyde. *A*, 1 : 10,0000 formalin; *B*, 1 : 10,000 formalin; *C*, 1 : 1,000 formalin; - - - -, untreated collagen fibres; ——, formalin-treated fibres

The reaction of aldehydes on collagen has been studied many times. It is generally accepted that at alkaline *p*H the terminal amino-group of lysine in the collagen reacts with formaldehyde to form a part of the cross-link[2]. Solomons and Irving[3] have shown that there is a direct relationship between the degree of mineralization in bone and the amount of bound lysine and hydroxylysine. The solubilization of hide collagen by concentrated acetic acid solutions also involved the lysine residue as shown by Elden *et al.*[4] from spectroscopic studies of collagen–acetic acid–formaldehyde interactions. In view of the similarity between the effect of aging and formaldehyde cross-linking on the length–time curves of tendon we suggest that collagen lysine and hydroxylysine might be involved in the changes taking place.

Wiederhorn *et al.*[5] cross-linked kangaroo tail tendon with formaldehyde and measured its elasticity after thermal shrinkage. The stress required for a fixed elongation was greater after the treatment. According to Flory[6], the force required to produce a fixed amount of strain must be higher with more cross-linking. At a fixed amount of force the elongation would be less. In the tendon of the kangaroo there was an increase in cross-linking with a reduction in the molecular weight between bridge points from 55,000 to 15,000.

The thermal shrinkage of collagen has features which suggest that it is a true phase-transition[7]. Solubilization by dilute acetic acid resembles the first step in a recently proposed two-step mechanism for the thermal conversion of the crystalline region of collagen to an amorphous phase. Contraction of tendons in 0·5 *M* acetic acid and 40 per cent potassium iodide is the mechanical consequence of such transitions. The thermally induced phase transition does not produce viscous-flow characteristics. Therefore, relaxation cannot proceed because of irreversible slipping of melted crystallites.

To sum up the above comments we have the following facts: (1) aging increases the extent of contraction but decreases relaxation of rat tail tendons. (2) Introducing cross-links by formaldehyde treatment affects the length–time curves in a manner comparable to the aging process. (3) The action of 40 per cent potassium iodide and acetic acid (0·05 *M*) are such as to induce a phase change with concomitant shortening of the tendons. Relaxation diminishes with aging. Under a fixed load the length of 'elastic' collagen decreases (contraction increases) when further cross-links are introduced. (4) Relaxation is due to the partial dissolution of the tendon by the solvent allowing the chains of collagen to unfold.

These facts are consistent with the concept that an increase in cross-linking of collagen occurs with aging.

H. R. ELDEN

Howard Hughes Medical Institute,
Miami, Florida.
Nov. 25.

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Electrical Conductance and Dielectric Constant of the Interior of Erythrocytes

THE electrical conductivity of an electrolyte is determined by its ion concentration. The effect of dispersed solid particles of a comparatively low conductance, such as proteins, can be taken into account using formulæ given by Maxwell[1] and Fricke[2]. Hence, an analysis of the electrical conductivity of the cell interior should provide information about the organization of its protoplasm.

In 1912, Höber[3] reported specific resistance values of the interior of beef erythrocytes between 160 and 600 ohm cm. Fricke and Morse[4] gave for beef and sheep erythrocytes 310 ohm cm. and Fricke and Curtis[5] later on for sheep, rabbit, chicken and turtle 140 ohm cm. Rajewsky and Schwan[6] and Cook[7] quote values of 100–110 ohm cm. for human erythrocytes. Measurements of Li and Schwan[8] indicate values near 200 ohm cm. for beef erythrocytes. In order to clarify whether these discrepancies reflect true species differences or differences in methods, additional investigations with erythrocytes of several species were undertaken[9]. Fresh heparinized blood was tightly packed by centrifugation. The erythrocyte sediment contained 2–5 per cent trapped plasma as judged from the consistency of calculated internal data with different packing factors and from the established performance of the hæmatocrit centrifuge[10].

Conductivity $\varkappa$ and dielectric constant relative to free space ε were measured with an admittance bridge (*RX*-Meter 250-*A*) from 0·5 to 250 Mc.

The reactance of the cell membrane vanishes[11] at about 70 Mc. Hence, $\varkappa$ and ε of completely packed erythrocytes are identical with internal values of the erythrocytes above 70 Mc./s. This was checked by investigation of the low-frequency conductance of erythrocyte suspensions after destruction of the insulating membrane with either saponin or toluene. Measured values were corrected for the small amount of trapped plasma in order to obtain values characteristic of the interior. This was done by use of equations given by Fricke[2]. While the exact validity of these formulæ may be questionable, no significant error should result from this procedure.

Results are summarized in Table 1 for seven different species. The internal resistance between the different animals varies by not more than 15 per cent. Differences are significant within 3 per cent. However, the dielectric constants of the several species, accurate to 1 dielectric unit, are not significantly different. The average of all dielectric constants values is 52 and close to previously published values[6]. It is due to the hæmoglobin content of the cells corresponding to a dielectric decrement of about 0·7 unit per gm. hæmoglobin per 100 c.c.[11]. The internal conductivity cannot be readily explained by the known electrolyte content, even if an activity coefficient of a 0·2 *M* potassium chloride solution is assumed and the non-conducting volume of the hydrated hæmoglobin is considered. The calculated conductivity values are higher than the internal results reported above by a factor of 2. Partial binding of ions to protein and reduction of their mobility may provide explanation for this fact. Similar discrepancies are indicated in the case of liver cells[9,12], frog muscle[13], and nerve fibres[14]. This suggests that the lower conductance is a general property of cell plasm.

Table 1. INTERNAL SPECIFIC RESISTANCE ρ, CONDUCTIVITY $\varkappa$ AND DIELECTRIC CONSTANT ε OF RED BLOOD CELLS (Temperature, 25° C.)

Species	ρ [ohm cm.] 90 Mc./s.	$\varkappa$ [m.mho/cm.] 90 Mc./s.	ε (250 Mc./s.)
Man	193	5·18	50·1
Beef	230	4·35	51·3
Sheep	228	4·39	50·4
Dog	216	4·63	50·9
Cat	190	5·26	53·1
Rabbit	170	5·89	55·1
Chicken	204	4·90	52·1

The work was supported in part by the U.S. Office of Naval Research (*NONR*-551(05)) and in part by the U.S. Public Health Service (*USPH*-1253 *C* 5).

I wish to thank Prof. H. P. Schwan for his interest and continued advice.

H. PAULY

Electromedical Division,
Moore School of Electrical Engineering,
and
Department of Physical Medicine,
School of Medicine,
University of Pennsylvania,
Philadelphia 4.

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Synthetic Activity of Polynucleotide Phosphorylase from Sperm

POLYNUCLEOTIDE phosphorylases are enzymes that catalyse the synthesis of polyribonucleotides.

No evidence has yet been given for the presence of polynucleotide phosphorylase in extracts of animal tissues, although these enzymes have been found in extracts of aerobic or anaerobic Gram-positive or Gram-negative bacterial cells[1–4].

A polynucleotide phosphorylase was isolated and partially purified from the human sperm. The enzyme was prepared from vacuum-dried human sperm by the method of Littauer and Kornberg[5]. The preparation obtained was further purified by ammonium sulphate fractionation, and by zinc ethanol precipitation. The precipitate obtained, between 15 and 20 per cent, was adsorbed on an equal volume of calcium phosphate gel. The pure enzyme was then eluted from the gel and activity determined.

The enzymic reactions were carried out in solutions where each 5·0 ml. portion contained *M*/10 trihydroxymethyl-amino-ethane buffer, *p*H 8·0, *M*/60 magnesium chloride, *M*/15 of either adenosine-5′-diphosphate, guanosine-5′-diphosphate, uridine-5′-diphosphate or cytidine-5′-diphosphate, each alone or in pairs, and 0·5 ml. of 5 per cent solution of the sperm enzyme.

Chromatograms of the reaction solutions were developed by the descending technique in two dimensions. The solvent systems used were ammonium–*iso*butyric acid and tertiary amyl alcohol–formic acid–water[6,7]. Permanent records of the chromatograms were obtained by the photographic technique[7]. The polynucleotides located were cut out from the chromatograms and eluted. The ultra-violet absorption spectrum, chemical identity and concentration were studied.

Table 1. STOICHIOMETRY OF REACTIONS CATALYSED BY SPERM PHOSPHORYLASE

	Nucleotides	Ortho-phosphate	Polynucleotides
Initial	ADP 9·8	1·0	ADP 0·0
90 min.	ADP −5·5	+6·0	ADP +5·0
Initial	GDP 9·4	1·0	GDP 0·0
90 min.	GDP −5·0	+6·0	GDP +5·0
Initial	UDP 9·6	1·0	UDP 0·0
90 min.	UDP −5·2	+6·0	UDP +5·0
Initial	CDP 9·6	1·0	CDP 0·0
90 min.	CDP −5·4	+6·0	CDP +5·0
Initial	ADP+GDP 19·8	2·0	ADP . GDP 0·0
90 min.	ADP+GDP −10·5	+12·0	ADP . GDP +10·0
Initial	ADP+UDP 20·0	2·0	ADP . UDP 0·0
90 min.	ADP+UDP −10·8	+12·0	ADP . UDP +10·0
Initial	ADP+CDP 19·4	2·0	ADP . CDP 0·0
90 min.	ADP+CDP −10·2	+12·0	ADP . CDP +10·0
Initial	GDP+UDP −19·0	2·0	GDP . UDP 0·0
90 min.	GDP+UDP −10·0	+12·0	GDP . UDP +10·0
Initial	GDP+CDP 19·0	2·0	GDP . CDP 0·0
90 min.	GDP+CDP −10·6	+12·0	GDP . CDP +10·0
Initial	UDP+CDP 19·9	2·0	UDP . CDP 0·0
90 min.	UDP+CDP 10·8	+12·0	UDP . CDP +10·0

ADP, Adenosine-5′-; GDP, guanosine-5′-; UDP, uridine-5′-; CDP, cytidine-5′-phosphates.

Homopolymers of adenylic, uridylic, guanylic and cytidylic acid with several heteropolymers containing the adenylic-guanylic, adenylic–uridylic, adenylic–cytidylic, guanylic–uridylic, guanylic–cytidylic and uridylic–cytidylic are found in the above enzyme reaction solutions (see Table 1). The enzymic activities of the polynucleotide phosphorylase provide a possible explanation of the differences in composition and structure of ribonucleic acids.

ANWAR A. HAKIM

Biochemical Research Laboratories,
Miami Heart Institute,
4701 North Meridian Avenue,
Miami Beach 40, Florida.

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Influence of Vitamin D on Synthesis of Hexosamine by Rachitic Rat Cartilage

IT is believed that chondroitin sulphate or its protein complex plays a very important part in the process of calcification[1]. The fact that during calcification there is a marked increase in metachromatic staining in the region which exhibits calcification led Rubin and Howard[2] to postulate that either there is an increase in the concentration of the mucopolysaccharide or that there is a change in its state of polymerization. In the former case it is possible that the enzyme system responsible for synthesizing chondroitin sulphate or some of its components would show an increase during the healing of rickets brought about by vitamin D, just in the same manner as the citric acid content and the enzyme concerned with its formation were found to show an increase in the rachitic epiphyseal cartilage of rat and dog after vitamin D administration[3]. Castellani and Zambotti[4] have recently demonstrated that the epiphyseal cartilage of growing rabbit contained appreciable amounts of a thermolabile enzyme system which synthesizes one of the components of chondroitin sulphate, namely, hexosamine from glutamine and glucose-6-phosphate. In view of these considerations, it was felt desirable to investigate whether vitamin D influenced the enzymatic synthesis of hexosamine in the rachitic cartilage.

For this study young albino rats, four weeks old, were fed a rachitogenic diet[5] for two weeks. At the end of this period the rachitic animals were divided into two groups, taking litter and sex distribution into account. Animals in group 1 served as rachitic controls; those in the other were each administered a single dose of vitamin D (4,000 I.U.) 96 hr. earlier. The animals from both groups were killed on the same day, and cartilage from the distal end of femur and the proximal end of tibia was removed from the four rats in each group. The pieces of cartilage were pooled, weighed and ground in a chilled mortar with a known volume of a cold solution of 10^{-2} *M* glutamine and 10^{-2} *M* glucose-6-phosphate in 0·1 *M* citrate buffer (*p*H 6·4), and hexosamine formed enzymatically was determined as described by Castellani and Zambotti employing Schloss's method[6]. As shown in Table 1 there is an appreciable rise in the hexosamine-synthesizing capacity of the rachitic rat cartilage as a result of vitamin D administration.

Table 1. EFFECT OF VITAMIN D ON THE ENZYMATIC FORMATION OF HEXOSAMINE BY RACHITIC RAT EPIPHYSEAL CARTILAGE

No. of observations	μgm. Glucosamine/gm. wet tissue in 3 hr.				
	Rachitic *A*	96 hr. after vitamin D *B*	*B* — *A* *S.E.*	*t*	*P*
5	267 (19)	459 (20)	192 ± 38·5	4·97	< 0·01

Number of rats employed is indicated in parentheses.

It was therefore logical to expect that on administration of vitamin D to rachitic animals the concentration of chondroitin sulphate or its hexosamine component in the cartilage would show an increase. This point was therefore investigated. Young rats were made rachitic as described above and distributed equally into four groups. Animals in group 1, which served as rachitic controls, were killed and their tibial epiphyseal cartilage quickly removed, placed individually in tubes and dried at 75° C. for 4 hr. Animals in the other groups were administered a single dose of vitamin D (4,000 I.U.), killed 48, 96 and 144 hr. later and the tibial cartilage was scooped out and dried. The dried cartilage was weighed and hydrolysed with 3·0 ml. 4 *N* hydrochloric acid at 100° C. for 12 hr. The hydrolysate was made to volume in a 10 ml. volumetric flask and aliquots taken for hexosamine determination. As shown in Table 2, there is a small, but significant, fall in the hexosamine content of rachitic rat cartilage during healing induced by vitamin D.

Table 2. EFFECT OF VITAMIN D ON HEXOSAMINE IN μGM./MGM. DRY RACHITIC RAT CARTILAGE

Rachitic controls	Hours after vitamin D treatment		
	48	96	144
Group 1	2	3	4
S.E. 117·8 ± 5·55	*S.E.* 97·5 ± 4·00	*S.E.* 89·3 ± 6·25	*S.E.* 87·3 ± 3·74
	Between groups 1 and 2	Between groups 1 and 3	Between groups 1 and 4
t	2·97	3·41	4·56
P	< 0·02	< 0·01	< 0·001

It was indeed surprising that although vitamin D enhanced the capacity of the healing cartilage to synthesize hexosamine enzymatically, there was no commensurate increase in the hexosamine content of cartilage, which in fact showed a slight decrease. It is difficult to reconcile these two contradictory observations. Further work might throw light on this interesting problem.

P. K. DIKSHIT

Nutrition Research Laboratories,
Indian Council of Medical Research,
Coonoor, South India.

Nov. 18.

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Incorporation of Labelled Thymidine in the Seminal Vesicle of the Mouse

IT has been reported that labelled adenine is incorporated into the deoxyribonucleic acid of the seminal vesicle of the mouse at a rate far exceeding that required for cell-division in the organ[1]. In view of the implications of this finding it seemed desirable to repeat the experiment with ^{3}H-thymidine, which can be regarded as a specific precursor for deoxyribonucleic acid[2]. The present communication deals with the incorporation in the seminal vesicle and, for comparison with a dividing tissue, in the œsophagus of the same animals.

Eleven mice of an inbred strain were injected intraperitoneally with 16·7 μc. each of ^{3}H-thymidine with a specific activity of 360 mc. per m*M*, supplied by Messrs. Schwarz Inc., Mount Vernon, N.Y. Animals were killed 1–7 days later, organs were fixed for 1 hr. in acetic acid–alcohol followed by 24 hr. in formol saline, embedded in paraffin wax and sectioned at 5–6μ thickness. Autoradiographs of unstained or Feulgen-stained sections were prepared by the stripping-film technique and exposed for 13 or 23 days. Unstained specimens were stained with Ehrlich's hæmatoxylin and eosin after photographic processing. The background of the autoradiographs is 0·3–0·5 grains per nucleus.

A number of nuclei of epithelial cells of the seminal vesicle are labelled 24 hr. after injection. The intensity of labelling after 13-days exposure averages 15 grains per positive nucleus in the seminal vesicle, compared with 13 grains per positive nucleus in the basal layer of the œsophagus. The most heavily labelled nuclei show up to 50 grains in both tissues.

Table 1. COMPARISON OF LABELLING OF DEOXYRIBONUCLEIC ACID AND CELL DIVISION IN THE SEMINAL VESICLE AND ŒSOPHAGUS OF MICE

	SI (per cent)	*MI* (per cent)	$\frac{SI}{MI}$
Seminal vesicle	4·4 ± 0·9	0·05 ± 0·02	88
Œsophagus	18 ± 1·1	9·5 ± 1·0	1·9

SI, No. of labelled nuclei per 100 cells 24 hr. after injection of labelled thymidine.

MI, No. of metaphases per 100 cells after 6 hr. treatment with colchicine.

$\frac{SI}{MI}$, the ratio of labelled cells to dividing cells as scored under the experimental conditions in this investigation.

No corrections for absorption of β-particles or loss of material through sectioning of nuclei of different size have been made. Furthermore, it is by no means certain that the supply and dilution by the pool of unlabelled thymidine of the injected ^{3}H-thymidine are the same for œsophagus and seminal vesicle. It can, however, be concluded that those nuclei which incorporate labelled thymidine do so at approximately the same rate in both tissues, though differences may be masked by the sources of error mentioned.

The seminal vesicle of mice killed 24 hr. after injection contains 4·4 ± 0·9 per cent (Table 1) labelled nuclei while the basal layer of the œsophagus shows 18 per cent. Analysis of the movement of labelled nuclei in the Malpighian layer of the œsophagus indicates that the differentiating cells are replaced every 2–3 days[3], so that the relatively low figure of 18 per cent labelled nuclei indicates that labelled thymidine is used up 8–12 hr. after injection, in agreement with data recently published by Hughes *et al.*[4]

The number of nuclei incorporating ^{3}H-thymidine is thus four times higher in the basal layer of the œsophagus than in the seminal vesicle ; the ratio of cell division should be similar in the two tissues if all incorporation were in preparation for mitosis. Allen[5], however, has found only 40 mitoses per 100,000 cells after 6 hr. treatment with colchicine, equivalent to 160 divisions per 100,000 cells per day or an average life-span of approximately 600 days. Mitotic counts on sections adjacent to those used for autoradiography and on Feulgen-stained sections of mice killed 6 hr. after injection with colchicine agreed with Allen's data (Table 1). No signs of cell degeneration such as pycnosis or extrusion of cells into the secretion were observed. Measurements of the amount of deoxyribonucleic acid per nucleus by means of Feulgen-photometry (Richards, B. M., private communication) in polymorphs and nuclei of the seminal vesicle gave a narrow range of diploid values. No intermediate or polyploid values were found.

Incorporation of ^{3}H-thymidine into the deoxyribonucleic acid in the seminal vesicle of the mouse is therefore approximately forty times higher than could be expected from the known rates of proliferation in this organ. This excess is far beyond the limits of error of the techniques employed.

Depending on the length of time during which thymidine is available, the rate of incorporation in 4·4 per cent of the nuclei of the seminal vesicle is equivalent to a renewal of 4·4–13 per cent of its deoxyribonucleic acid per day. From the rate of incorporation of labelled adenine a renewal of 10 per cent per day was calculated[1]; the two methods therefore agree as well as can be expected.

The proportion of labelled nuclei is well maintained up to seven days after injection. Cell counts and grain counts undertaken so far suggest a decline between the third and seventh day, which, however, may not be significant in view of the small number of animals used in this investigation.

Since most of the incorporation of ^{3}H-thymidine in the epithelial cells of the seminal vesicle does not lead to mitosis a metabolic function of this process has to be assumed. Metabolic activity of deoxyribonucleic acid was originally discovered by means of the incorporation of labelled phosphate in rat liver by Ahlstrom, v. Euler and Hevesy[6]. The results of later experiments which give similar results have been reviewed in a previous communication[1]. They lead to the conclusion that deoxyribonucleic acid is metabolically almost completely stable in adult brain, cartilage and muscle, that it is renewed at a rate approaching 1 per cent per day in normal rat liver and pancreas, and proceeds at a rate similar to that found in dividing tissues in Jensen rat sarcoma, transplantable mouse mammary carcinoma, lung, intestinal mucosa, mouse prostrates grown in organ culture and in the seminal vesicle of the mouse.

It is of interest to note that our findings, similar to recent observations on incorporation of labelled thymidine in bean roots[7], suggest that all, or at least most, of the deoxyribonucleic acid contained in nuclei is taking part in metabolic activity which therefore is unlikely to be connected with genetic specificity of deoxyribonucleic acid.

We wish to thank Dr. H. B. Fell for much helpful discussion and Prof. J. T. Randall for his interest and for providing facilities.

S. R. PELC
P. B. GAHAN

Medical Research Council
Biophysics Research Unit,
King's College, London, W.C.2.
Nov. 4.

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Terminology of Hormones

A NEED has been felt for a precise terminology to distinguish four types of animal hormones by their actions[1,2]. (1) 'Metabolic' hormones stimulate or inhibit clearly defined metabolic processes. This term is in general use for such hormones as thyroxine and a secretion from the insect corpus allatum, both of which increase oxygen consumption, or for the hydrocortisone-like hormones from the adrenal cortex and a neuro-secretion from the insect brain, both of which increase diuresis. (2) 'Morphogenetic' hormones promote growth and cell differentiation. This term can be used for thyroxine when it has a morphogenetic action in stimulating amphibian metamorphosis. The hormone, ecdysone, from the prothoracic gland of some insects is also morphogenetic, since it promotes moulting and ecdysis. There is obviously some overlap between the hormones in these two groups, since no growth can occur without the support of many metabolic processes ; but metabolic actions can occur without growth and can usually be examined and described independently. The distinction in terms can help to clarify this.

(3) These hormones control the relatively rapid and repeatable actions of effector organs. They form a very distinct group, for which we propose the term 'kinetic', since no other name has been generally accepted. They include oxytocin and other hormones acting on muscles, chromactivating substances from the ganglionic X-organ–sinus gland complex of crustaceans acting on retinal cells and chromatophores and secretin among those controlling exocrine glands. They have been referred to as energetic[3]; but this is not a term that distinguishes them clearly from metabolic hormones. Great confusion surrounds the use of the suffixes trophic or tropic not only for some of these kinetic hormones, as in chromatophorotropic, but also for some of the morphogenetic hormones.

(4) Those kinetic hormones which stimulate the secretion of another hormone from an endocrine gland can be usefully distinguished by the rational, if not euphonious, term 'endocrinokinetic'. This includes hormones from the vertebrate adenohypophysis, such as thyrotrophin and adrenocorticotrophin, and also the interstitial-cell-stimulating hormone and luteotrophin. On the other hand, the follicle-stimulating hormone, which stimulates the growth and maturation of gonads, is mainly morphogenetic and so is the luteinizing hormone, since it promotes growth of the corpus luteum but does not stimulate it to secrete. The use of 'gonadotrophic' for all these four does not distinguish between their actions. The best known example of an endocrinokinetic hormone from an invertebrate is that which comes from the insect brain and stimulates the secretion of ecdysone.

D. B. CARLISLE

Marine Biological Association Laboratory,
Plymouth.

PENELOPE M. JENKIN

Department of Zoology,
University of Bristol.

Nov. 25.

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Changes in the Osteoblastic and Mitochondrial Population of Aging Periosteum

EARLY investigators[1-4] interested in the physiology of bone have described filamentous, rod- and granular-shaped mitochondria in osteoblasts from a variety of animals both *in vivo* and *in vitro*. An apparent relation between the number of mitochondria and osteoblastic activity was also pointed out. Pritchard[5] arrived at the same conclusion. Within the past decade numerous biochemists have revealed a good many of the substrates and enzymes involved with intermediary metabolism associated with mitochondria. More recently, cytochrome oxidase and succinic dehydrogenase activity of the periosteum was studied in normal and traumatized rat femora from birth to old age[6,7]. The results showed high levels of activity of respiration becoming more elevated at the period of maximum rate of bone formation. Following this period of intense activity (5 weeks of age), a sharp drop occurred to a low level, which was maintained throughout the life of the animal. Trauma to the femora stimulated a response of respiratory activity, however, the response becoming progressively less with increasing age. Changes in respiratory enzyme-levels are fundamental to the activity of cells in general, because these enzymes are part of the aerobic hydrogen transport system from which rich-energy-bond phosphate is generated.

Since cytochrome oxidase and succinic dehydrogenase have been shown to be associated with mitochrondria[8], it was concluded that perhaps the changes in enzyme, noted with increasing age, reflected mitochondrial variations which resulted in changes in osteoblastic population. These alterations will be expected to effect the physiological functions of the periosteum in the processes of growth of bone and healing of fractures.

The experiments were performed to study the following: (1) quantitative changes in the osteoblastic population and their mitochondrial complement during the process of aging; (2) to relate these results to the previous respiratory enzyme findings; (3) to furnish a base-line for future studies of cytological changes associated with healing of fractures from birth to old age.

Long–Evans strain rats were used in the experiments and were divided into six age-groups containing ten animals each. Group I consisted of 1 week-old rats, Group II, 5 weeks-old, Group III, 8 weeks-old; Group IV, 26 weeks-old; and Groups V and VI, 52 weeks- and 104 weeks-old animals, respectively. Each group was subdivided into males and females. Intact femoral periosteum was obtained by shaving the mid-shaft of each bone. This method ensured the histological and cytological integrity necessary for proper measurements and eliminated the need of decalcification. Frozen sections were made and stained with janus green *B*. Additional tissues were fixed immediately with Regaud's fixative. Paraffin sections were prepared and stained with Regaud's iron hæmatoxylin.

Periosteal osteoblasts and their mitochondrial complement in contact with the preosseous zone were counted at each age. Special precautions were taken to count only the mitochondria of intact, non-distorted, free osteoblasts. The numerical data were evaluated for significance by statistical methods using Fisher's *t*, having a critical ratio of 2·797 and a probability of $P < 0\cdot01$.

Counts made of the number of periosteal osteoblasts adjacent to the preosseous zone revealed a slight

Table 1. A COMPARISON BETWEEN THE AVERAGE NUMBER OF OSTEOBLASTS PER UNIT AREA AND THE AVERAGE NUMBER OF MITOCHONDRIA PER OSTEOBLAST AT THE FEMORAL PERIOSTEUM OF RATS OF VARIOUS AGES

Age (weeks)	1	5	8	26	52	104
Average number of osteoblasts per unit area ± S.E.	10·2 ± 0·5	10·6 ± 0·4	10·5 ± 0·2	2·8 ± 1·9	3·5 ± 0·5	1·1 ± 0·2
Average number of mitochondria per osteoblast ± S.E.	28·4 ± 1·3	37·1 ± 2·4	16·8 ± 0·9	17·9 ± 1·4	9·5 ± 0·6	3·3 ± 0·5

S.E., standard error of the mean.

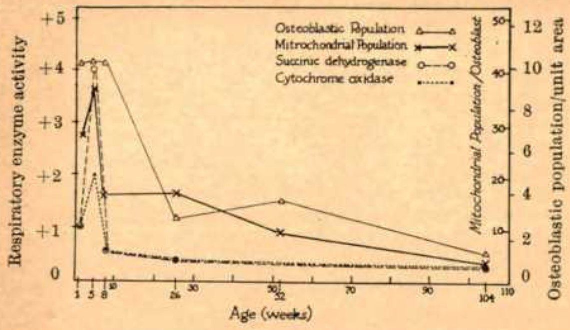

Fig. 1. A composite graph showing the relation between the shape of several curves at various ages. Note that the respiratory enzyme curves (succinic dehydrogenase and cytochrome oxidase) are similar to the mitochondrial population curve, and that the fall in respiratory enzyme activity and mitochondrial numbers precedes the disappearance of the osteoblasts from the periosteum

increase from birth to 5 weeks of age. This number was maintained to about 8 weeks of age, after which time there was a very significant fall in the number of osteoblasts in this region to 26 weeks of age. The following groups revealed a continued but less-severe diminution in the number of osteoblasts (Table 1). The mitochondrial complement of these cells also varied coincidentally with the variations noted in the number of osteoblasts. Mitochondria increased in number from birth to 5 weeks of age; however, only half this number was found by 8 weeks of age. The following ages revealed a progressive reduction in the mitochondrial complement (Table 1). A comparison of the number of osteoblasts, mitochondria and previously reported respiratory enzyme activity of the osteoblasts is given in Fig. 1. Morphological variations in osteoblasts were seen to occur following the numerical changes described (Fig. 2).

The results showed that a quantitative relation between the number of mitochondria and osteoblastic activity does exist, as has been pointed out by earlier investigators. It has also been shown that these changes precede the loss in the number of osteoblasts at the preosseous zone. Additional support is given by a comparison with respiratory enzyme findings[6,7], which were seen to parallel the mitochondrial changes. It is interesting to note that the reported drop in respiratory enzymes occurred also before the fall in the number of osteoblasts and that the greatest enzyme activities, number of mitochondria, and osteoblasts occur coincidentally with the period of maximum rate of bone formation in the rat. It appears, therefore, that during the processes of periosteal aging, biochemical changes are occurring associated with the mitochondrial complement of osteoblasts which are intimately involved with the long-recognized variations in the rate of bone growth and the observed morphological changes seen in ageing periosteal osteoblasts.

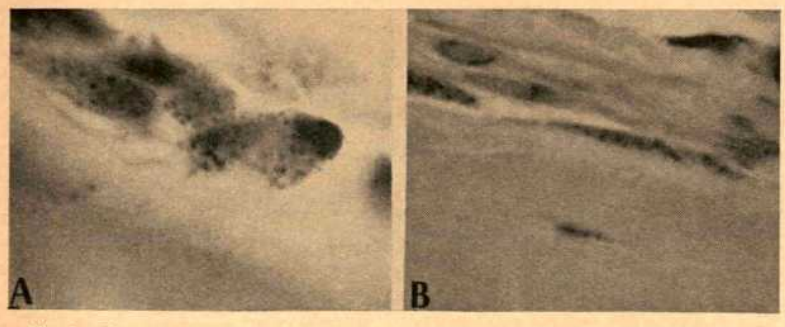

Fig. 2. Photomicrographs demonstrating the morphology of the periosteal osteoblasts and their mitochondrial complement in: (A) a 5 week-old rat and (B) a 1 year-old rat. Stained by Regaud's iron hæmatoxylin method. (× c. 700)

E. A. TONNA
N. PILLSBURY

Department of Histo-Cytochemistry,
Hospital for Special Surgery,
New York.

Nov. 13.

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BIOLOGY

Differential Response of Male and Female Adults of *Trogoderma granarium* Everts towards Sterilizing Doses of Gamma-radiation

DURING a recent investigation into the tolerance of adults of *Trogoderma granarium* Everts to sterilizing doses of γ-radiation, it was decided to separate the sexes before treatment.

Previous work by Cornwell *et al.*[1] had shown that most insect pests of stored products could be sterilized by a dose of 6×10^3 rep. (In the present work, the rad has been used as the unit for measuring radiation. This unit has been adopted internationally for use in biological work in preference to the roentgen (r.), and the rep, both of which have been used in other works cited. The numerical differences between the three units are sufficiently small to enable reasonably accurate comparisons to be made between the results of others and the present work.

The work described here is a result of several trials with the adults of *T. granarium* which have shown that a dose of 5×10^3 rads (administered from a cobalt-60 source at 570 r. per min.) is sufficient to sterilize only the females of the species. The males (Table 1) are able to retain some fertility at dosages up to 15×10^3 rads, which is three times that required to sterilize the females.

It is interesting to compare this result with those of Bushland and Hopkins[2], who investigated the resistance of screw-worm flies, *Callitroga hominivorax* (Coq.), towards sterilizing doses of γ-radiation. In that case (where the insects were irradiated as pupæ) the sexes were also treated separately. In direct contrast to the present work, however, it was discovered that the males required less γ-radiation than the females to render them sterile. The males, in fact, were almost completely sterilized by a dose of $2 \cdot 5 \times 10^3$ r. given on the seventh (penultimate) day of the pupal stage. On the other hand, females laid eggs (which yielded a 50 per cent hatch) after being given a dose of 4×10^3 r. on the seventh day after pupation.

Table 1. NUMBER OF LARVÆ PRESENT AT EACH OBSERVATION. AFTER TREATMENT, EXCEPT AT THE HIGHEST DOSAGE, SEVEN MALES WERE CONFINED WITH TWICE THEIR NUMBER OF NORMAL NEWLY EMERGED FEMALES

Days after exposure of males	No. of larvæ present following γ-irradiation of males (dose in rads)			
	0	5,000	10,000	15,000*
3				
4				
5	5			
6	10	2	1	
7	30	4	3	
8		6	7	
9				
10		20		3
11		20	14	5
12			14	8
13		26	14	
14			16	
15				
16			16	
17			20	
18				
19			20	
20				
21	40	26	20	8

* Thirty males were irradiated and confined with thirty females.

Table 2. NUMBER OF MALES FOUND DEAD AT EACH OBSERVATION

Days after exposure	No. of males dead after dose (rads)			
	0	5,000	10,000	15,000
4	4	1		
5	2	1		4
6	0	1	1	5
7	1	3	4	5
8		1	2	12
9				3
10		26		1

The adults of *T. granarium* were irradiated immediately on emergence from the pupæ. Thus the difference between the resistance in the two sexes, when compared with *C. hominivorax*, cannot be attributed to irradiation of the insects at widely different stages in the development of the two species.

Some of the results (Table 2) indicate a possible increase in life-span following irradiation, and it is hoped to investigate the significance of such results in future work.

G. C. CARNEY

Department of Agricultural Zoology,
School of Agriculture,
University of Durham,
King's College,
Newcastle on Tyne.
Oct. 19.

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Measuring Productivity in Breeding of Small Animals

IT is nearly always desirable, when breeding animals like mice for laboratory use, to select for high productivity, that is, for the largest number of healthy offspring per dam in a given time. This is a function of litter size and 'pre-natal interval'; the time between exposure to the chance of mating and the birth of the first litter, or the time between the births of successive litters. The pre-natal interval is only of interest for monogamous pairs which are never separated.

Carter[1] suggested that the measure of productivity be the number of mice born and weaned, divided by the number of prenatal days. This index will be less than 1·0, occasionally less than 0·1, and to be useful it will contain two significant figures. Later it was suggested[2] that the reciprocal of Carter's index be used which will be a figure greater than 1·0 and occasionally greater than 10·0—also needing to have two significant figures. Carter's index is inconvenient owing to the decimal point; but it varies indirectly with the productivity. The other figure is more convenient but still contains a decimal point; however, it varies inversely with the productivity, which is an added inconvenience.

Thanks to a suggestion made by D. S. Falconer (personal communication), we now propose to use Carter's index multiplied by 100 as a measure of productivity, and to call this index Q. It will always be less than 100, and in most cases more than 10: a typical range will be between 15 and 35. No decimal points are involved. We further propose to call Q the 'index of productivity', and to calculate it cumulatively from the date of the first exposure to the chance of mating to the birth of successive litters up to the last. This index gives, in a convenient form, a current measure of productivity of pairs of animals, on which selection can be based.

W. LANE-PETTER
ANNIE M. BROWN
MARGARET J. COOK
G. PORTER
A. A. TUFFERY

The Laboratory Animals Centre,
Medical Research Council Laboratories,
Woodmansterne Road,
Carshalton, Surrey.
Dec. 2.

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An Unusual Strain of *Escherichia coli* in Septicæmia as an example of the Transformative Effect of Symbiosis

A 54-YEAR-OLD male patient was admitted to hospital with signs of septicæmia and obstructive jaundice after having suffered from gall-bladder troubles for the past five years. By blood culture in brain–heart infusion broth a rich growth of a highly polymorphous Gram-negative organism was obtained (Fig. 1, top) which gave the typical biochemical reactions of an *Escherichia coli* and a positive hæmagglutination test. The macroscopic appearance of the colonies also did not differ from a slightly mucoid *E. coli* culture. No dwarf colonies were found. The polymorphism (filaments with broad swellings, globular and club-shaped forms) was most marked on a culture 24–48 hr. old on 5 per cent rabbit blood agar. After three days the majority of the filaments had broken up into chains of rods and the bizarre forms had disappeared. This aberrant morphology persisted for ten months if the strain was subcultured only on blood agar. After this time it grew in more or less uniform short filaments. If subcultured exclusively on plain agar, it reverted after five months to the typical size and shape of *E. coli*. No morphological change could now be brought about by transferring it from plain to blood agar.

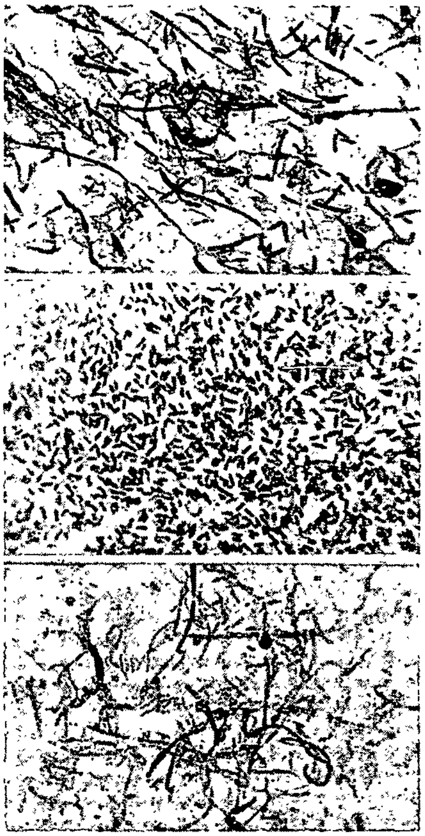

Fig. 1. Top, *E. coli* from blood, shortly after isolation, showing filamentous and swollen forms in a 24-hr. culture on blood agar; middle, bacillary form of the same strain, as in top, after five months subculturing on plain agar; bottom, the same bacillary variant as in middle, re-transformed into the aberrant form under the influence of a *Paracolon* strain. (× *c.* 670)

The patient's serum agglutinated the strain up to a dilution of 1/5,000, but the usual routine agglutinations (*Salmonella*, *Proteus X*, *Brucella* and *Leptospira*) were negative. Fifty control sera gave either negative results or titres below 1/100.

The strain was forwarded to the Statens Serum Institute, Copenhagen, for further investigation. The *coli H*-antigen 6 was found while the *O*-antigen could not be determined.

As a cholecystography showed an obstruction of the gall bladder, the patient was operated on and two stones removed from the common bile duct. Cultures on McConkey plates from bile obtained from the inflamed gall bladder during operation revealed the presence of scanty colonies of the same polymorphous *E. coli* as found in the blood together with many colonies of a quite different *Enterobacterium*. The latter one grew in short rods of uniform size and shape, formed on iron-triple sugar agar acid and gas only at the butt, utilized citrate, split urea and produced ammonia and indole but no hydrogen sulphate. It readily formed acid and gas from glucose and mannitol, but slowly from lactose and salicin. Saccharose, adonitol and inositol were not fermented. The hæmagglutination test was negative. On solid media, the growth was luxuriant but otherwise was not characteristic.

This second strain does not fit biochemically into any of the recognized types of Enterobacteriaceae. Belonging to the slow lactose fermenters, it might still be best to call it a *Paracolon bacterium*, although this group has lately been abolished by some authors[1].

The fact that the two strains were found together in the bile suggested the idea that this symbiosis was responsible for the morphological change of the *E. coli*. Therefore, we tried to re-induce the aberrant growth in its daughter strain from plain agar, which had changed back to the typical bacillary form, by culturing it together with the *Paracolon* in a liquid bile medium and by subsequent isolation on McConkey plates. This method failed because the *Paracolon* overgrew and destroyed the *E. coli* within two or three days. In the gall bladder, the *E. coli* was probably protected by mucus and exudate against antagonistic environmental influences, and in the intestines the *Paracolon* might not have been numerous enough to eliminate completely the *coli* strain. Our experiments succeeded, however, as soon as we applied a modified cross-streak technique, generally used for investigating antibiotic effects.

A segment of a blood agar plate was thickly inoculated with the *Paracolon* strain and incubated for two or three days. Now, a suspension of the bacillary *coli* strain was prepared and streaks were drawn with it perpendicularly to the edge of the *Paracolon* growth. Similar streaks were made on a separate blood agar plate as controls. After 24-hr. incubation, the controls showed rich uniform growth without morphological change (Fig. 1, middle). On the plate previously inoculated with the *Paracolon*, the growth of the *E. coli* was considerably inhibited but not completely abolished up to a distance of 20 mm. from the edge of the *Paracolon* growth and became gradually richer farther away. Morphologically, the bacillary variant was re-transformed to its previous filamentous form with its bizarre shapes (Fig. 1, bottom). This transformation occurred in the partly inhibited zone as well as in the uninhibited one.

Yet subcultures from the streaks on a fresh blood agar reverted to the bacillary form after 24 hr. if they were made within the first few days after the transformation into the aberrant form had taken place. If, however, the plates were sealed with 'Plasticine' in order to prevent exsiccation and the *E. coli* was kept in association with the *Paracolon* for three to four weeks, the filamentous phase proved to be much more stable in repeated subcultures on blood agar and it took about one month before it reverted to the bacillary form.

Neither inhibition nor morphological alterations could be induced by this method in a number of typical *coli* strains from stools.

It appeared to be most likely that the morphological change was brought about by a weakly antibiotic substance, probably a colicine[2,3], produced by the *Paracolon* and diffusing through the agar. Filament formation has been observed under the influence of growth inhibitors[4] but the organisms revert rather quickly to their original size as soon as they are brought back to normal conditions. We have seen the same in our transformation experiments of short duration. However, if subcultured on blood agar before a reversion to the bacillary phase occurred, our strain represented a fairly stabilized morphological variation, manifesting itself regularly at a certain period of growth by taking shapes which were similar to the *L* forms of *E. coli*[5]. Yet it did not grow in micro-colonies as is characteristic for true *L* forms. The comparative stability of our variant was obviously brought about by a long-lasting symbiosis with the *Paracolon*. This could be reproduced, to a certain extent, by the association of the two strains for some weeks.

So far as we are aware, this is the first time that the induction of a rather stable transformation of a bacterial strain by its symbiosis *in vivo* with another one has been recognized as such and could be experimentally reproduced. A detailed account of our experiments is to be published elsewhere.

We wish to express our thanks to Dr. F. Ørskov, Copenhagen, for examining the *coli* strain serologically and to Dr. H. Salomon, Haifa, for preparing the photomicrograms.

R. REITLER
M. TEICHER
A. VALERO

Government Hospital 'Rambam',
Haifa, Israel.
Nov. 17.

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An Antifungal Substance in the Corn Plant and its Effect on Growth of Two Stalk-rotting Fungi

IN a recent paper on root and stalk rot of field corn in south-western Ontario[1], we reported that stalk-rotting fungi do not invade the stalks of young corn plants. Subsequent experiments have been designed to investigate whether or not young corn stalks contain substances which will inhibit the growth of these fungi. Loomis *et al.*[2] found resistance factors in corn which were effective against the European corn borer, *Pyrausta nubilalis* (Hubn.), as well as *Penicillium chrysogenum* and other organisms. Virtanen *et al.*[3] isolated antifungal factors from wheat, maize and rye which inhibited *Fusarium* sp., *Penicillium* sp. and a wide range of other micro-organisms. In the present communication results are presented which demonstrate that extracts from young corn stalks inhibit growth of two stalk-rotting organisms, *Fusarium moniliforme* Sheld. and *Gibberella zeae* (Schw.) Petch.

Stalks of 52-day-old corn (Pioneer 349) were cut into small pieces and frozen. To 2,000-gm. samples of the frozen material, 1,000 ml. of distilled water was added and the mixture was boiled for 15 min. Juice, extracted from the mixture under pressure, was concentrated to 1,000 ml. by boiling. An ether extract from this juice was assayed for antifungal activity by measuring its effect on growth of *Fusarium moniliforme* and *Gibberella zeae*, which were grown on dehydrated Czapek's agar plus extract for 72 hr. at 25° C. The diameters of the colonies of *Fusarium moniliforme* on eight plates of Czapek's agar (control) and on eight plates of Czapek's agar plus extract averaged 4·10 cm. and 2·23 cm., respectively. This represents an inhibition of growth of 45·6 per cent caused by the extract.

Growth of *Gibberella zeae* was inhibited by 22·5 per cent.

In ten other lines of corn investigated, inhibition of *Fusarium moniliforme* ranged from 56·5 to 63·9 per cent.

The results of these experiments strongly suggest that stalks of young corn are not attacked by *Fusarium moniliforme* or by *Gibberella zeae* because of the presence of an antifungal substance in the young stalks.

N. J. WHITNEY

Science Service Laboratory,
Canada Department of Agriculture,
Harrow, Ontario.

C. G. MORTIMORE

Experimental Farm,
Canada Department of Agriculture,
Harrow, Ontario.
Oct. 15.

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Balanus tulipiformis Ellis on the Atlantic Coast of France

THE presence of *Balanus tulipiformis* Ellis on the Atlantic coast of Europe was recently recorded for the first time[1]. It was there noted that this species had been observed on the south-west coast of France from 1956.

It has since transpired that among the barnacles in the Musée de la Mer, Biarritz, there are two lots of *B. tulipiformis*, both found considerably earlier. These specimens had not been recognized as such, and had been labelled *B. amphitrite* Darwin. Samples from each of these exhibits have been examined by Dr. J. P. Harding, who has confirmed their identification as *B. tulipiformis*.

The earlier lot consists of about 30 young or half-grown specimens which had been thrown up on the beach at Messanges (Landes). They were collected by M. Paul Arné, some living and some dead, between 1923 and 1933. In the latter year, M. Arné left Messanges to take up the post of director of the newly opened Musée de la Mer, Biarritz, taking his collections with him. The later exhibit is a group of 10 or so large specimens, all joined together, which was found on a piece of rock brought up with a crayfish trap off Biarritz in 1950.

It is thus established that a quarter of a century has elapsed since *B. tulipiformis* was first found on the south-west coast of France.

B. S. KISCH

Saint-Jean-de-Luz,
Basses-Pyrénées,
France.
Dec. 9.

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Facultative Parasitism and Dietary Change in *Harmolita hyalipenne* Walker

DIETARY change from carnivory to phytophagy has been previously reported from four Eurytomidae; by Nielson[1] from Denmark for an unidentified species of *Eurytoma* parasitic on the larvæ of *Cryptocampus angustus* Htg. in willow twigs; by Rimsky-Korsakow[2] for *Harmolita inquilinum* (the U.S.S.R.) parasitic on *H. rossicum* in the stems of rye; and by Phillips[3] for *Eurytoma pater* Girault and *E. parva* Girault[4,5]

Table 1

Square No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Controls		
No of females introduced	10	1	2	5	5	1	2	2	4	2	1	1	5	1	0	0	0
No. of males	4	1	0	0	4	1	2	2	3	3	1	1	5	1	0	0	0
No. of galls	73	0	0	0	53	0	0	4	36	18	0	2	0	0	0	0	0

parasitic on the wheat joint worm *H. tritici* Fitch in the United States. In each case the eurytomid larva parasitizes its stem-living host larva, and having destroyed this becomes phytophagous in order to obtain sufficient nutriment for the completion of its development.

During an investigation into the species of Eurytomidae infesting the couch grass *Agropyron repens* Beauv. in Britain, *Harmolita graminicola* Giraud was found to be the main species inducing the formation of apical stem galls, while *H.* (*Eurytoma*) *hyalipenne* exhibited a facultative parasitism and played only a minor part in gall formation.

The female *H. graminicola* oviposits in June or July in the zone of elongation immediately below the apical meristem of the couch grass, and the single larva emerging from the egg feeds on the plant tissue inducing the formation of a fusiform apical gall. Its larva is bright yellow in its later instars and is easily distinguished from the white late instar larva of *H. hyalipenne*.

H. hyalipenne reaches a peak of emergence a few days later than *H. graminicola*, the females laying their eggs immediately above the final node of the stem which, however, usually forms the base of a young gall of *H. graminicola*, and, under natural conditions, the infested stems are selected for oviposition. The eggs are dark brown in colour, and from each an extremely active larva emerges which immediately attacks and destroys the gallicolous larva of *H. graminicola*, this still being in an early instar. The amount of food obtained from this brief parasitic period is small and insufficient for future development so that the larva then turns to the plant tissue, which it consumes until the onset of diapause.

It was decided in 1958 to test experimentally whether this parasitic part of the life-cycle was essential, since collections made in the field showed occasional galls in which there was no trace of the remains of *H. graminicola* larva, while an active *H. hyalipenne* was feeding inside the gall.

A series of square-yard samples of couch grass were cleared of galls by careful inspection and cutting the grass of the growth of the previous years. Over each square a butter-muslin cover was placed mounted on a wooden frame, and a known number of male and female *H. hyalipenne* which had been reared in the laboratory were then introduced into each square in July and allowed to oviposit on the stems.

After two months the covers were removed and the grass from each square cut and examined in the laboratory, where the galls were counted, the figures being shown in Table 1.

From this it is apparent that if *H. hyalipenne* females are deprived of stems infested by the larvæ of *H. graminicola* they will still continue to oviposit and their larvæ develop fully although unable to undergo a parasitic phase in their life-cycle. The galls which these larvæ produce are identical with those of *H. graminicola*.

When considering the life-cycles of the Eurytomidae where dietary change was then known, Gahan[6] inferred that phytophagy was a recent specialization arising from a parasitic life-cycle. Although *H. hyalipenne* shows a similar dietary change, its ability to dispense with parasitism in its larval stages and to develop normally by phytophagy indicates that the reverse may be true and that larval parasitism in this group is a more recent specialization.

R. BAILEY

Science Department,
Hatfield Technical College,
Hatfield, Herts.

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GENETICS

Selection for Relationships Opposite to those predicted by the Genetic Correlation between Two Traits in the House Mouse (*Mus musculus*)

THE majority of the concepts of population genetics used in predicting possible progress in livestock breeding are derived from the known behaviour of single genes. An exception to this is the concept of the genetic correlation between two traits which is based on the statistical partitioning of their variances and covariance[1]. The genetic portion of these variances and covariance is then used to estimate a probable change in one trait when the second trait is selected for. Falconer[2] has indicated the validity of this process for a particular case in that he obtained similar values for the genetic correlation between length of tail and body-weight in mice of six weeks of age from an experiment in which the response of each was measured when the other was selected for.

The genetic correlation in Falconer's experiment could be the result of pleiotropy or of linkage. If it resulted from pleiotropy of only a proportion of the genes concerned, then it should be possible to select for genes which affect tail length or body-weight only. A suitable selection method could then produce results opposite to those predicted by the genetic correlation. Some early results from such a selection experiment are available.

Initial stocks were obtained by inter-crossing the inbred lines *A^w C.57.Bl.* and *CBA* obtained from the Animal Genetics Section, Commonwealth Scientific and Industrial Research Organization, Sydney. All possible reciprocal crosses were made and the resulting progeny were then inter-crossed. Selection was started on mice from a second inter-crossing and made between all mice of the first litter in each generation with the only restriction being the avoidance of sib-matings. Males and females were selected separately and two litters were bred from each mating.

Selection was made on the deviations of the actual body-weight at six weeks from the expected value.

Table 1. THE MEAN LENGTH OF TAIL (CM.) AND BODY-WEIGHT (GM.) OF FIRST LITTER AT SIX WEEKS OF AGE FOR THE FINAL INTERCROSS AND FOR OFFSPRING OF SIX SELECTION GENERATIONS

Generation	Final intercross	S_1	S_2	S_3	S_4	S_5	S_6	Standard deviation S_6
Positive deviations				Males				
Tail length	8·6	7·8	8·5	8·2	8·0	7·7	7·8	0·46
Body-weight	20·9	16·6	24·3	23·2	22·3	23·3	25·4	1·61
Expected body-weight*	20·9	18·8	20·5	19·9	19·3	18·5	18·7	
Deviation	0·0	−2·2	+3·8	+3·3	+3·0	+4·8	+6·7	
				Females				
Tail length	8·3	7·7	8·1	8·2	7·8	7·5	7·9	0·23
Body-weight	17·3	16·7	19·6	20·0	18·4	20·0	20·7	1·58
Expected body-weight*	17·3	14·6	16·2	16·9	15·3	14·0	15·5	
Deviation	0·0	+2·1	+3·4	+3·1	+3·1	+6·0	+5·2	
Average litter size†	7·1	8·5	5·8	7·5	8·3	6·0	8·0	
Negative deviations				Males				
Tail length	8·6	8·1	9·0	8·9	9·0	9·6	9·7	0·42
Body-weight	20·9	19·1	23·2	20·4	23·0	22·7	21·1	1·50
Expected body-weight*	20·9	19·5	21·9	21·7	21·9	23·2	23·5	
Deviation	0·0	−0·4	+1·4	−1·3	+1·1	−0·5	2·4	
				Females				
Tail length	8·3	8·4	8·7	8·8	8·9	9·0	9·0	0·42
Body-weight	17·3	18·7	20·0	19·1	18·3	18·3	16·8	1·09
Expected body-weight*	17·3	17·7	19·1	19·4	20·0	20·1	20·3	
Deviation	0·0	+1·0	+0·9	−0·3	−1·7	1·8	−3·5	
Average litter size†	7·1	7·3	4·8	6·0	6·3	6·8	7·3	

*Estimated from genetic regression (see text), ♂♂; $y = 2{\cdot}5X - 0{\cdot}7$
♀♀: $y = 4{\cdot}2X - 17{\cdot}5$

†Eighteen matings in the final intercross, four matings in each selection generation

This expected body-weight was estimated from the observed length of tail by use of the regression of body-weight on length of tail. Lines for positive and negative deviations were selected and for the first three generations the regression used was that calculated from the litters of previous generations. Subsequent selection has been by use of the regression within the first three generations of the positive and negative lines. Regressions for males and females were calculated separately.

Table 1 shows the length of tail and body-weights at six weeks for the first litters of six selection generations. The standard deviations shown are those for the offspring of the sixth generation. Selection for positive deviations has resulted in mice with shorter tails and greater body-weight than those arising from selection for negative deviations.

Estimates of the genetic correlations made from the initial crosses gave values of 0·66 for males and from 0·77 to 0·92 for females. For this type of estimate these values are in reasonable agreement with those of 0·57 and 0·62 obtained for both sexes by Falconer[2]. The genetic components of variance and covariance used to obtain the correlation were also used to calculate a regression of body-weight on length of tail. It is this regression which has been used to obtain the expected values of body-weight shown in Table 1.

These results show that it is possible to make fairly rapid progress in selection for relationships between two traits different from those predictable from the expected correlated response. An explanation based on a hypothesis that a proportion of the genes are pleiotropic for length of tail and body-weight is reasonable, but the alternative explanation of linkage of the genes concerned and selection of appropriate recombinants must be considered in this experiment. Mather and Harrison[3] have concluded that an observed correlated response in *Drosophila melanogaster* was the result of polygenic linkage. This is less likely in mice with their greater number of chromosomes and hence a lesser chance of any two genes being linked. However, if pleiotropy is concerned, then further selection for tail length alone should eventually give the appropriate correlated response of body-weight as the pleiotropic genes should still be present. If linkage was the cause of the original correlation and these linkages have been broken, as suggested by Mather and Harrison[3], then no correlated response of body-weight should follow continued selection for length of tail alone. These alternative possibilities are now being tested.

Whatever the underlying cause, it is clear that in this case the presence of a genetic correlation does not preclude the possibility of a rapid response to selection for various combinations of the correlated traits. Whether this is true in other cases may well depend on whether or not there is a unique physiological basis for the traits measured.

I should like to acknowledge the advice and encouragement of Prof. A. L. Rae. This work was supported by a grant from the New Zealand Department of Scientific and Industrial Research.

F. COCKREM

Sheep Husbandry Department,
Massey Agricultural College,
Palmerston North.
Oct. 9.

[1] Lerner, I. M., "Population Genetics and Animal Improvement" (Cambridge University Press, 1950).

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PSYCHOLOGY

Association between Psychomotor Behaviour and Delinquency

IN 1948, Davis[1] reported experimental evidence of significant association between manner of movement of controls in a simulator cockpit and (*a*) neurotic syndromes and (*b*) accident proneness among pilot trainees. In 1955, Venables[2] reported experimental results confirming Davis's finding (*a*) above, also (*c*) non-significant correlation of psychomotor response variable with general intelligence and (*d*) significant association of response pattern, on a task of graded difficulty, with subsequent job-dismissal in a small industrial group ($n = 18$).

The relation between psychomotor behaviour in this test situation (replicating the procedure described by Venables[2]), and subsequent delinquency (the criterion of delinquency, by Service classification, includes minor offences not thus classifiable by civil usage) in a large sample of Royal Air Force recruits to a relatively low-skilled trade, has been studied in a research for the Air Ministry, with results summarized below. (Theoretical implications are the subject of a separate report.) Initially, the finding of non-significant correlation between general intelligence and the psychomotor variate, and of the continuous unimodal distribution of the variate, was confirmed for the Royal Air Force population. Venables' preferred variate was the ratio of amplitude of manual responsive movement to time taken in making the movement; this measure has been used in logged form. The subject moves a knob in a slot, right or left and back to centre, in response to visual signals. The signals are presented in three series, of which the first (*A*) and last (*C*) are similar and relatively easy and the second (*B*) difficult for all subjects. The difficulty of response to *B*-series lies in the speed and complexity of presentation of the signals in the series as a whole. The stimuli for the responses which are scored, and the type of responsive movement required, are the same in all three series. The subject does not see the record of his movements.

Response to the three series tends to be made at a characteristic score-level, so that the series scores are correlated positively with a high degree of significance (product-moment r in a 20 per cent random sample of all subjects tested to a given date with $n = 251$ were: AB, $+0{\cdot}88$; AC, $+0{\cdot}87$; BC, $+0{\cdot}87$). Some individuals tend to reduce and some to increase score with change of difficulty of task; the direction of change has been found to be significantly associated with temperamental factors in the previous researches quoted. In this investigation both the general score-level and the degree and direction of the difficulty gradient were found significantly predictive of delinquency (service plus civil) over a period of up to 19 months subsequent to the administration of the test.

The results of two analyses are shown below, the first based on records of all tested entrants to training in the trade in question, over a given period ($n = 601$), the second a more detailed analysis of a smaller sample ($n = 157$). The crime record criterion was on a dual basis: (1) number of convictions, and (2) penalty awarded; categories ranged from zero on both counts to 3 or more convictions for offences of which at least one was indictable or penalized as serious by the Service authority. Psychomotor-test mean scores and variances were calculated for all groups and various combinations of groups. In the first study the non-delinquent group included: (1) men without record of conviction; (2) men convicted of one minor Service crime only; (3) men withdrawn from trade training for technical reasons only. The delinquent group included (1) men with several or serious offence records; (2) men withdrawn from trade training owing to unsuitability of character. Mean score differences were significant between the delinquent/non-delinquent groups but not within these groups. With the accumulation of additional records, the later study was restricted to group (2) of the non-delinquents and group (1) of the delinquents. More than 80 men were subjects of both studies, many appearing in different crime groups on the two occasions, owing to accumulation of individual crime records.

Table 1. PSYCHOMOTOR TEST SCORES OF NON-DELINQUENT AND DELINQUENT GROUPS: INITIAL SERIES AND DIFFICULTY GRADIENT SCORES

Series	Non-delinquents $n = 567$ Mean	Non-delinquents $n = 567$ Variance	Delinquents $n = 34$ Mean	Delinquents $n = 34$ Variance	P of difference between means
A	195·6	1,494	220·1	1,694	$< 0{\cdot}001$
$A-B$	3·24	420·4	13·03	629·2	$< 0{\cdot}05$
$B-C$	−6·39	438·7	−14·03	346·8	$< 0{\cdot}02$

Table 2. PSYCHOMOTOR TEST SCORES OF NON-DELINQUENT AND DELINQUENT GROUPS VARIOUSLY CLASSIFIED: DIFFERENCES BETWEEN MEAN SCORES ON INITIAL SERIES AND DIFFICULTY GRADIENTS

Groups compared $n(1)$–$n(2)$	One minor crime with the rest 107/50		One crime with multiple crime 125/32		Minor crime with serious crime 119/38	
Series	Difference between $\bar{x}$	P	Difference between $\bar{x}$	P	Difference between $\bar{x}$	P
A	−−19	$<0{\cdot}01$	−25	$<0{\cdot}01$	−22	$<0{\cdot}01$
$A-B$	− 5·6	$>0{\cdot}05$	− 7·4	$>0{\cdot}05$	− 9·5	$<0{\cdot}01$
$B-C$	+ 3·5	$>0{\cdot}05$	− 0·7	$>0{\cdot}05$	+ 6·2	$<0{\cdot}01$

It was found that the delinquent groups differed significantly from the non-delinquent both in manner of reaction to reduction of task difficulty ($B - C$ score), confirming Venables's finding[2], and also, more significantly, on all primary series scores, of which only *A* score is shown in Tables 1 and 2. They also differed significantly in manner of reaction to increase in task difficulty.

The psychomotor variate was interpreted by Davis as anticipatory tension, closely related to anxiety. It seems that anxiety is relatively chronic or diffuse in relation to the easier task, relatively specific or objective in relation to the more difficult task. By these investigations, association is established between psychomotor behaviour and delinquency, the association being interpreted in terms of level of chronic or diffuse anxiety and manner of reaction to change of specificity of the source of anxiety.

H. S. ANTHONY

Science 4,
Air Ministry,
London.
Nov. 11.

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Effect of Reduction of Stimulation on Consumption of Food, Intake of Water and Weight of Body in Rats

RECENT work on factors determining the amount of general activity in animals indicates that such activity is related to: (*a*) the presence of stimuli previously associated with the diurnal cycle; (*b*) stimulus variety in the environment. However, the evidence is suggestive rather than conclusive, the main difficulty arising from the lack of specifiability and measurement of 'general' activity. We therefore investigated a readily measurable behaviour pattern, namely, eating and drinking.

Two hooded male rats, approximately 4 months old at the beginning of the experiment, were tested over a period of six months. The apparatus consisted of a cage measuring 13½ in. long, 9½ in. high and

Table 1

Trial	Unrestricted environment				Trial	Restricted envirronment			
	No. of responses	Food consumed (gm.)	Water intake (c.c.)	Weight change (gm.)		No. of responses	Food consumed (gm.)	Water intake (c.c.)	Weight change (gm.)
Rat 1					Rat 1				
1	733	18·4	9·5	10	2	555	13·8	7·8	0
3	702	17·5	8·8	5	4	527	13·2	7·5	10
5	712	17·8	8·8	15	6	526	13·1	7·8	0
7	721	18·0	9·0	5	8	529	13·2	7·8	0
9	718	17·9	9·0	0	10	530	13·2	7·5	0
Mean	717·0	17·9	9·0			533·4	13·3	7·7	
Rat 2					Rat 2				
1	620	15·5	8·0	35	2	427	10·7	6·5	5
3	632	15·8	7·2	0	4	440	11·0	7·0	0
5	605	15·1	7·5	10	6	468	11·7	6·8	5
7	597	14·9	8·0	10	8	452	11·3	6·8	0
9	609	15·2	7·5	0	10	443	11·1	6·5	0
Mean	612·6	15·3	7·6			446·0	11·1	6·7	

8 in. wide, fitted with a lever. When the lever was pressed, powdered food (0·025 gm.) was delivered from a concealed food hopper into a recessed food trough placed to the left of the lever. The apparatus could be enclosed in a sound-proofed box which was suspended in a sound-proofed chest. The apparatus (including control equipment) stood in the experimenter's office. The inner box was ventilated by an air pump and was constantly illuminated by a 15-watt lamp. The apparatus and subjects were kept for 4 days inside the chest, and then for 4 days the apparatus was placed, exposed, on top of the chest. Thus the animal was alternately subjected to reduction (environmental restriction) and variety of stimulus.

Table 1 gives the results for animals 1 and 2 respectively. Each trial period lasted for 4 days. The results cover the last 40 days of the experiment and consist of the mean daily frequency of pressing of the lever, the mean daily amount of food consumed (gm.), the mean daily amount of water drunk, and the change in weight during the trial, under each of the experimental conditions.

Statistical tests support the conclusion that the effect of reduction of stimulation (restricted environment) is to reduce the animal's food consumption and intake of water, as well as to inhibit temporarily gain in weight. During the restricted environment phase of the experiment, the food consumption of animal 1 fell off by 25·7 per cent and intake of water by 15 per cent. The food consumption of animal 2 fell off by 27·2 per cent and intake of water by 12·4 per cent.

This research was supported by the Central Research Fund, University of London.

KARL WEISS
HARRY M. B. HURWITZ
Department of Psychology,
Birkbeck College,
London, W.C.1. Nov. 7.

Threshold Values for Taste in Monozygotic Twin Calves

ELECTROPHYSIOLOGICAL studies have shown that specific taste receptors are distributed in definite topographical arrangements on the tongue of man and laboratory animals[1,2]. More recently, similar studies have been extended to include domesticated ruminants[3]. Taste discrimination has been demonstrated in a variety of laboratory animals[4,5] and using this type of preference test, threshold values for rejection and acceptance of a variety of sapid substances have been established for a number of different species.

Discrimination tests for taste have now been carried out using monozygotic twin calves as subjects. Monovular calves were chosen for investigation for two reasons; first, in order to extend knowledge of sensory discrimination and especially of the sense of taste to another species, and secondly, to find out whether monovular cattle twins show the same close similarity in the inheritance of physiological sensory thresholds as they do for anatomical and biochemical factors[6].

The 'two-choice' discrimination tests for cattle were carried out in a manner like that devised for the goat[7]. Each calf was kept in a similar specially fitted stall, and feeding and management were standardized so far as possible. The front of each animal's stall allowed access to two identical polythene buckets suitably fixed at ground-level; normally, these buckets were kept filled with tap water. For the test a known concentration of test substance in solution in tap water was placed in one bucket and tap water only in the other bucket. The position of the test solution was reversed the next day to offset any bias due to visual or behavioural cues. For each single concentration of solution the aggregate amount consumed in the right and left position was used in assessing the results. The amount of test solution taken during the two test periods of nine hours on consecutive days was calculated as a percentage of the total fluid intake, that is, volume of test solution ingested and volume of water ingested.

The results for the whole group of calves and different sapid solutions are presented graphically in Figs. 1–4. It can be seen that high concentrations of test substance are usually rejected almost completely, the small amounts taken being only sufficient to stimulate the animals' taste receptors. The rejection threshold has been placed arbitrarily at the lowest concentration where not more than 20 per cent of the total fluid intake has been consumed. The ideal acceptance threshold, the level at which animals do not discriminate between test solution and tap water, would be the level when 50 per cent of the total fluid intake is the test solution. In practice this value probably lies between 40 and 60 per cent of the total fluid intake. The mean values for rejection and acceptance thresholds for all calves for the four normal taste modalities of sweet, sour, salt and

Table 1. GUSTATORY THRESHOLDS OF CALVES TO THE FOUR TASTE MODALITIES OF BITTER, SOUR, SALT AND SWEET. THE NUMBER IN BRACKETS REFERS TO THE NUMBER OF ANIMALS TESTED

Substance		Threshold concentration (moles)	
		Rejection	Acceptance
Quinine dihydrochloride	(12)	0·000097	0·000024
Acetic acid	(8)	0·026	0·0083
Sodium chloride	(8)	0·42	0·105
Glucose	(8)	—	1·11

bitter are shown in Table 1. In the case of sweet (glucose) taste sense there does not appear to be a true rejection threshold value.

The threshold values obtained between the different animals of the group shows a very much wider range than that shown between the individuals of a twin-set. The mean of the results for all the calves tested is plotted in Figs. 1–4 together with the values for the individuals of a monozygous twin-set. In an attempt to make the tests more rigorous and to eliminate environmental factors the individual members of the set of twin calves shown in Figs. 1–4 were separated by a distance of 15 miles, one of each set being housed at Potters Bar and the other at Camden Town. (The broken line in Figs. 1–4 is the mean of all the calves tested. The open and closed circles are the results obtained from the individuals of a monovular twin set, one of which was housed at Potters Bar and the other at Camden Town.) Furthermore, the test solutions were offered on different days at Potters Bar and Camden Town and the personnel dealing with the animals was different at the two places. The 'within-set' taste discrimination and consequently the close similarity of gustatory thresholds of calves is shown in Figs. 1–4. It would appear from the close relationship of the 'within-set' differences obtained that taste discrimination was almost entirely genetical in origin, and that environmental factors play only a minor part in this type of behavioural reaction.

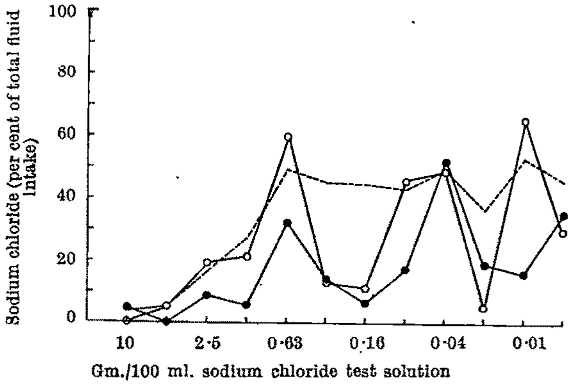

Fig. 1. Sodium chloride taste preference tests

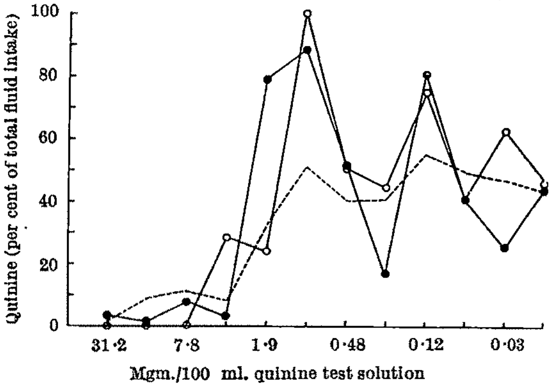

Fig. 2. Quinine taste preference tests

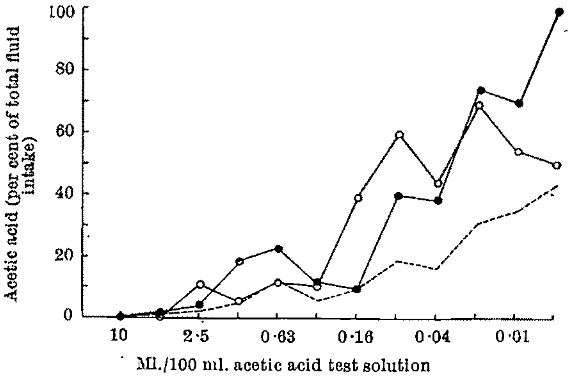

Fig. 3. Acetic acid taste preference tests

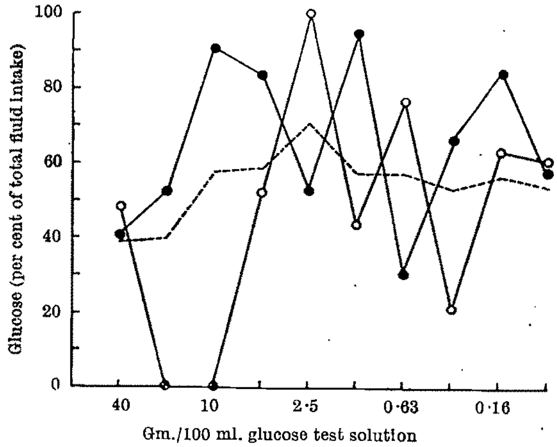

Fig. 4. Glucose taste preference tests

These results afford further evidence of the value of monozygotic twins as subjects for experimental research in the larger animals. Monovular twin cattle will obviously be the experimental animals of choice in the design of experiments to study physiological sensory mechanisms and nervous pathways in ruminants, for each pair will provide a control and experimental subject, thus reducing the high costs associated with experimental investigations of these large ungulates.

This work will be reported in detail elsewhere. We wish to express our thanks to the Agricultural Research Council for financial assistance and to B.O.C.M., Ltd., for generous supplies of animal foods.

F. R. BELL
H. L. WILLIAMS

Departments of Physiology and Animal Husbandry,
Royal Veterinary College,
London, N.W.1.
Nov. 25.

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FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, February 2

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. I. C. Cocking: Presidential Address.

University of London Institute of Education (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Prof. H. J. Eysenck: "The Principles of Conditioning and the Theory of Education".*

Society of Chemical Industry (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. D. A. Wright: "The Selection and Control of Semiconductors for Different Applications".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Dr. Waldo Lyon: "Trans-Polar Voyage of U.S.S. *Nautilus*".

Tuesday, February 3

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. L. S. Palmer: "Examples of Geoelectric Surveys".

Institution of Mechanical Engineers, Lubrication Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Informal discussion of the paper by Mr. N. F. Rieger: "An Experimental Investigation of the Pressurized Air-Lubricated Journal Bearing in the High-Speed Range".

Society for Analytical Chemistry, Biological Methods Group (joint meeting with the Biometric Society, in the Small Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Scientific Papers.

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. F. R. G. Gimblett: "Polymers and Derivatives of Phosphonitrile Chloride".

Wednesday, February 4

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. D. G. R. Bonnell: "The Mechanization of Building Constructional Processes" (Alfred Bossom Lecture).

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. D. Anson: "A Radioactive Corrosion Probe".*

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. D. H. Tullis, Mr. L. C. Neill and Mr. A. T. Henderson: "Control of Marine Organisms in a Salt-Water Cooling System".

University of London (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1). at 5.30 p.m.—Prof. G. De Santillana (Massachusetts Institute of Technology): "Space in Antiquity and the Renaissance".* (Further lecture on February 6.)

Society of Chemical Industry, Food Group—Nutrition Panel (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Dr. G. D. Rosen: "Practical Implications of the Laboratory Evaluation of Protein Quality".

British Institution of Radio Engineers, Computer Group (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Inaugural Meeting.

Society for Analytical Chemistry (in the Meeting Room of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Meeting on "The Estimation of Pesticide Residues".

Royal Institute of Chemistry, London Section (joint meeting with the South-West Essex College of Technology Chemical Society, at the South-West Essex College of Technology, Forest Road, London, E.17), at 7.30 p.m.—Dr. S. F. Birch: "Petroleum Chemicals".

Thursday, February 5

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. J. Lloyd: "Water for the Swiss Jura".*

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. A. H. Cooke, Mr. J. H. E. Griffiths, Mr. B. R. Judd, Mr. R. Lazenby, Mr. F. R. McKim, Mr. J. Owen, Mr. J. G. Park, Mr. M. F. Partridge and Mr. W. P. Wolk: "Exchange Interactions in Antiferromagnetic Salts of Iridium. 1: Paramagnetic Resonance Experiments. 2: Magnetic Susceptibility Measurements. 3: Theory of the Interaction".

Institute of Refrigeration (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Dr. H. J. Goldsmid: "Thermoelectric Cooling".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. T. H. Mason, Dr. P. D. Aylett and Mr. F. H. Birch: "Turbo-Generator Performance under Exceptional Operating Conditions."

Royal Anthropological Institute (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. J. H. M. Beattie: "Neighbourliness in Bunyoso".

University of London Institute of Education (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Prof. L. J. Lewis: "Partnership in Oversea Education"* (Inaugural Lecture).

Royal Aeronautical Society (at Hatfield Technical College, Hatfield, Herts), at 6.15 p.m.—Mr. J. L. P. Brodie: First Halford Memorial Lecture.

Society of Chemical Industry, Microbiology Group (joint meeting with the Agriculture Group, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Dr. Bond and Mr. R. Cooper: Two papers on "Nitrogen Fixation".

Polarographic Society (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Polarographic Problems Encountered in the Semi-Conductor Field" introduced by Dr. V. J. Jennings.

Royal Institute of Chemistry, London Section (joint meeting with the Kingston Technical College Chemical Society, at the Kingston Technical College, Fassett Road, Kingston), at 7 p.m.—Prof. M. Stacey, F.R.S.: "Fluorinated Hydrocarbons".

Friday, February 6

University of London (in the Meyerstein Lecture Theatre, Westminster Medical School, Horseferry Road, London, S.W.1), at 5.15 p.m.—Prof. L. T. Samuels (University of Utah): "Studies of Steroid Biosynthesis in Testicular Interstitial Cells".*

Institution of Electrical Engineers, Medical Electronics Discussion Group (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Problems of Storing Transient Phenomena for Subsequent Analysis" opened by Dr. P. Bauwens and Mr. P. Styles.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. V. E. Cosslett: "Microscopy with X-Rays".

Saturday, February 7

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. R. A. Skelton: "Captain James Cook's Voyages in the South Seas and their Scientific Value".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Assistant (Computational) (preferably with a degree and interested in the application of numerical methods to chemical problems) in the Department of Chemistry—The Registrar, The University, Manchester (February 7).

Senior Lecturer or Lecturer (with special qualifications in pure mathematics) in Mathematics—The Registrar, The University, Manchester 13 (February 7).

Pig Breeding Advisor (agricultural graduate with good post-graduate experience in the scientific aspects of animal breeding and a sound practical knowledge of pig breeding), for duties concerned with advising at farm level on pig breeding problems including those arising in connexion with pig recording and progeny testing—The Establishment Officer, Pig Industry Development Authority, Pida House, 15–17 Ridgmount Street, London, W.C.1 (February 10).

Senior Research Assistant (preferably with a knowledge of electron optics and vacuum physics), for experimental research on the aberrations of electron lenses—The Secretary of the Department of Physics, Cavendish Laboratory, Free School Lane, Cambridge (February 14).

Lecturer (with an honours degree in zoology, specialized in agricultural entomology, and experience in pest control and plant protection) in Entomology in the School of Agriculture, Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (February 18).

University Assistant Lecturer (preferably specialized in applied mathematics and theoretical physics) in Mathematics—The Secretary of the Appointments Committee of the Faculty of Mathematics, The Arts School, Bene't Street, Cambridge (February 18).

Lecturer, an Assistant Lecturer, and Research Fellows in the Department of Physics—The Deputy Registrar, The University, Birmingham 15 (February 19).

Assistant Lecturer in Geography—The Registrar, The University, Leicester (February 21).

Assistant Lecturer in the Department of Agriculture (Crop Husbandry)—The Registrar, University College of Wales, Aberystwyth (February 21).

Chair of Geology—The Registrar, The University, Leicester (February 21).

Research Assistant (preferably with experience in electron microscopy, electronics and vacuum physics), to operate and maintain a Siemens electron microscope in the Metal Physics Group of the Cavendish Laboratory—The Secretary of the Department of Physics, Cavendish Laboratory, Cambridge (February 21).

Research Fellows (Ph.D. standard, with special aptitude for research in high or low energy nuclear physics) in Experimental or Theoretical Nuclear Physics—The Registrar, The University, Liverpool (February 21).

Chair of Mathematics (Theoretical Mechanics)—The Registrar, The University, Southampton (February 28).

Lecturer in Zoology in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (February 28).

Lecturer or Assistant Lecturer in Botany at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 28).

Reader in Classical Archæology—The Secretary of Faculties, University Registry, Oxford (February 28).

William Cochrane Chair of Metallurgy tenable at King's College, Newcastle-upon-Tyne—The Registrar, University Office, 46 North Bailey, Durham (February 28).

Lecturer in Physics—The Secretary and Registrar, The University, Southampton (March 4).

Lecturer in Botany at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 6).

Lecturer (qualified in the field of palæontology, particularly micropalæontology) in Geology at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 9).

POSTDOCTORAL FELLOW (with a Ph.D. degree in physical chemistry, preferably high polymer chemistry, radiation chemistry or some branch of reaction kinetics) IN THE DEPARTMENT OF PHYSICAL CHEMISTRY—Prof. F. S. Dainton, School of Chemistry, The University, Leeds (March 15).

RESEARCH FELLOWS (2) IN THE DEPARTMENT OF NUCLEAR PHYSICS, Research School of Physical Sciences, Australian National University —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 16).

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IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOW IN CHEMISTRY, OR PHYSICS—The Secretary, The University, Exeter (March 23).

LECTURER IN BOTANY (PLANT PHYSIOLOGY) at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 31).

SENIOR LECTURER IN SOIL MICROBIOLOGY, and a SENIOR LECTURER IN FARM MANAGEMENT at the Institute of Agriculture, University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 31).

HEAD (male of high scientific attainment with wide research experience either in soil science or in a relevant basic subject such as physical chemistry) OF THE DEPARTMENT OF PEDOLOGY—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (April 6).

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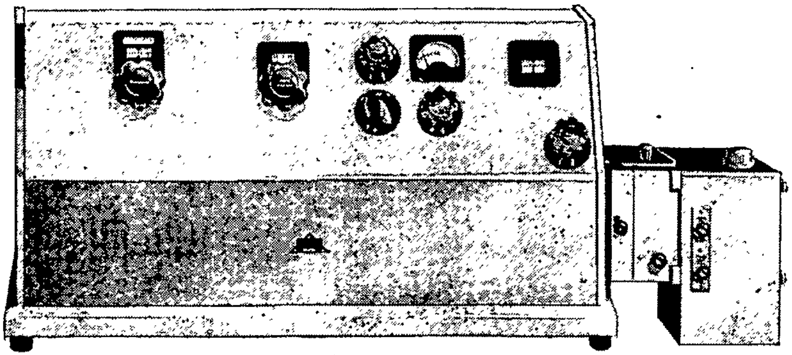

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The Faraday Society

The Council of the Faraday Society have accepted an invitation from the National Research Council, Ottawa, and Canadian Industries to hold a

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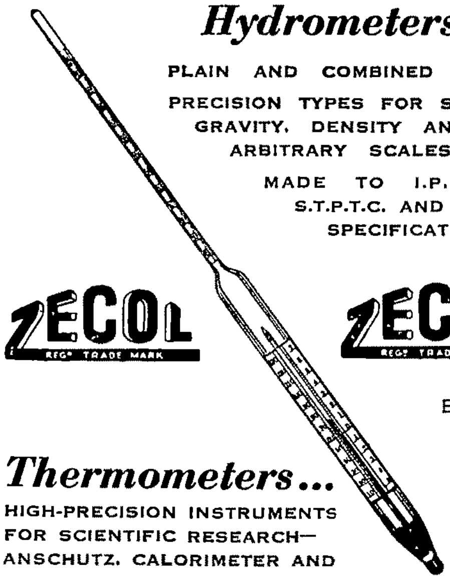

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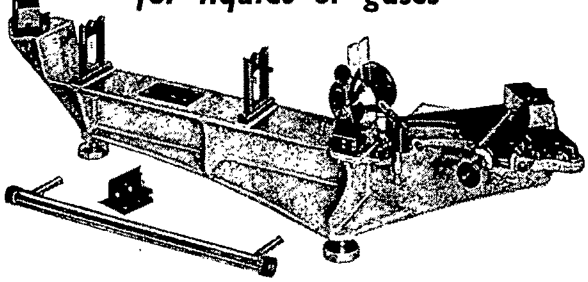

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CHURCHILL COLLEGE, CAMBRIDGE

ON January 24 the University of Cambridge passed without opposition a grace giving recognition to the proposed Churchill College as an approved foundation from the first day of the first term in which it admits students. Although outwardly no different from any other congregation in the Senate House, this was a historic occasion, for it marked the first approval of a new foundation for men in Cambridge since Selwyn College was admitted in 1882, and it means that the Trustees can now seek a Royal Charter and that Churchill may proceed in due course to achieve full status as a College of the University on equal terms with the older foundations. In its development to this stage of formal approval, the project has, naturally enough, met with some criticism in the University; but this has been less serious and less widespread than it has at times appeared to be from statements in the Press. The main lines of criticism have been on matters of procedure, on the clearly stated intention to have a numerical ratio of seven to three in favour of science and engineering in the student body, and on the vexed question of the desirable size of the University of Cambridge as a whole. Of the two latter, it has been pointed out, not unreasonably, by supporters of the project, that the growing importance of science and the current movement towards it in universities and more especially in our schools will, in any event, lead in the near future to a general bias in entries not unlike that proposed for Churchill and that since, under present conditions, pressure on entry to the University is so heavy, it is surely wiser to found a new college than to allow the system to be further weakened by a creeping inflation of existing foundations. It is significant that the grace approving Churchill College was accepted unopposed in the Senate House.

It is now little more than seven months since the Trustees launched their appeal, and the fact that more than £2,832,000 has already been subscribed, mainly by British industry, is a remarkable tribute both to the imaginative concept of a Churchill College and to Lord Knollys and his colleagues on the Appeal Committee. True, this sum still falls short of the original target by more than £650,000; but the Trustees hope that at least this sum may be obtained by their further efforts combined with those of the associated Churchill Foundation which, under the leadership of Mr. Carl Gilbert, chairman of the Gillette Co., is working to the same end in the United States. Already, however, the funds available ensure a firm foundation for the new College, and a number of steps have been taken to speed its development.

Building sites within easy reach of the main University precinct in Cambridge are nowadays difficult to find, but the Trustees have been fortunate in being able to purchase from St. John's College a large open site to the west of the river within 1½ miles of the city centre in an area close to that proposed for the new buildings for New Hall and Fitzwilliam House, to the Observatories and to the new University development area on the Madingley Road site. Bounded on the north and east by Storey's Way, on the south by Madingley Road and on the west by the grounds of the Observatories, the site extends to some 41 acres and will accommodate not only the College buildings but also its playing fields. Building a new College in Cambridge is an exciting project, and many different architectural approaches are possible. For this reason, if for no other, it was probably a wise decision to invite twenty firms of architects to enter a limited competition. The competition will be judged by a panel consisting of two Trustees and three distinguished architects, and it is hoped that the winning design will be translated into action within the year. The Trustees have given no indication of their own views on building; but it is hoped that the opportunity will be taken to build in the modern idiom, and to provide in the College buildings a permanent record of the best in mid-twentieth century architecture.

It has, of course, been clear that early appointment of the first Master of Churchill College would be necessary, since the beginning of a building programme will quickly bring in its train problems which require the Master's decision. Moreover, in preparing for the admission of students and in the initial stages of its work, a Master of outstanding quality is necessary if the College is to build itself into the Cambridge pattern and, at the same time, introduce new ideas and methods, and avoid the pitfalls which constructive criticism in the University has pointed out. The choice of Sir John Cockcroft as first Master will be widely acclaimed. Not only is he a brilliant physicist with a strong sympathy for engineering, but also his work in developing the Atomic Energy Research Establishment at Harwell has shown him to be an outstanding scientific administrator. More than this, he has long shown a strong interest in scientific education, and he is widely known as a man with a deep affection and respect for Cambridge and its traditions. With Sir John in charge, Churchill College should be off to a good start.

The announcement that future appointments to the Mastership will be made by the Crown has given rise to some discussion. Crown-appointed masters exist in two colleges only—Trinity College, Cambridge, and Christchurch, Oxford—the common practice elsewhere being for masters to be elected by the Fellows themselves. Each system has its merits and demerits, but the evidence from Trinity and Christchurch suggests that appointment by the Crown can be very successful, and it provides at least some guard against the 'safe' but undistinguished elections made at times under the other system.

It is no easy task to build such a complex organism as a Cambridge College from scratch, particularly when it is sought to blend science and the arts in a predetermined ratio. Recruitment of staff and selection of students both present their own problems, and a gradual building-up process will be necessary; but these difficulties are offset by the opportunity to break new ground educationally. In their original memorandum the Trustees laid particular stress on postgraduate training in science and engineering for both home and overseas students, and they emphasized the need to encourage men to return from industry for a period of study and research. The provision of laboratory facilities and courses for such purposes will be the task of the University departments of science and engineering, but, through its tutorial facilities and specialist Visiting Fellowships which it hopes to maintain, Churchill College can make a new and important contribution to the Cambridge scientific scene. Much has been said and written about the need for a closer welding of science and the arts in our system of university education. Churchill College has the opportunity to experiment in this field, too, and we may hope that under Sir John Cockcroft's guidance it will not be overlooked. For teachers we must have, and, if Churchill College can produce men to lead in teaching as well as in industry, then it will indeed fulfil the high hopes of its Trustees and of its many benefactors and well-wishers.

NEURO-MATHEMATICS

The Computer and the Brain

By Dr. John von Neumann. (Mrs. Hepsa Ely Silliman Memorial Lectures.) Pp. xiv+82. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1958.) 24*s*. net.

THIS book constitutes the last writing to come from this eminent mathematician, a short account of whose life and last illness leading to his tragically early death in 1957 is given in a preface to the book by Klara von Neumann. The manuscript, intended for the Silliman Lectures in 1956, was never finished.

The first half of the book summarizes the characteristics of man-made computers. It distinguishes between analog and digital machines and the degrees of precision attainable in each, between parallel and serial methods of computation, between plug-board and memory-stored control, between active (arithmetic) units and inactive (memory) units, and discusses access times, memory capacities and so on.

The second half of the book compares the natural nervous system with artificial computers. It appears that the natural 'computer element'—the neurone—has a rather slow reaction time (10^{-2} sec.) compared with modern artificial devices. Von Neumann further implies that the method of transmitting information by digital pulse trains, interpreted in terms of pulse-time density to give digital-type logical information but analog-type quantitative information, will reduce the effective 'computing speed' by a factor of ten for each effective decimal place of accuracy. The loss of an occasional digit, however, would not be disastrous in the method of operation described.

On the other hand, he suggests that the effective memory capacity of the nervous system must be, and could plausibly be, of order 10^{20} decimal digits, in order to record a life-time of experienced sensations.

The overall picture is that the brain is, compared with modern machines, a very reliable and compact computer, with a low speed and a low order of accuracy in individual calculations, but an enormous (inactive) memory capacity, a large (active) arithmetico-logical assembly (highly parallel operation), and great economy in power requirements.

Von Neumann then argues as follows: since the brain has to control such a highly complex organization as the human body, it must carry out long (arithmetically deep) calculations. The brain cannot work to 10 or 12 decimal accuracy, which we know to be necessary in artificial computers, to retain two or three figure final accuracy. Hence, he argues that some different and unknown form of mathematics must be employed in the brain to produce its satisfactory results, and that conventional mathematics and brain-language stand in the same relation as an interpretive code to basic machine language, or vice versa.

In this connexion there are two relevant points, the first being hinted at by von Neumann himself, and the second, perhaps, being a point which he would have included in the book if he had been given time. First, the loss of accuracy at each stage of a long calculation may, perhaps, be eliminated by carrying out a large number of independent calculations at each stage, and evaluating the results statistically. By reason of its large 'active' assembly the brain would be well equipped to do this.

The second point is this: when planning a computation one has the choice between calculating everything *ab initio* (suitable for fast, small-memory machines) or using 'tabulated' results of earlier auxiliary calculations (suitable for slow, large-memory machines like the brain). The reviewer therefore suggests that the brain never does any arithmetically deep calculations—it merely makes minor interpolations, variations and extensions to a vast stock of 'tabulated solutions' which it has been accumulating (on a basis of trial and error and statistical selection) in its memory throughout the course of its development from a single cell. Really basic problems, like digestion of food and circulation of the blood, have perhaps been tabulated pre-natally for reference in this way. Slightly less basic problems, like learning to walk, have not been solved prior to birth, and it takes the infant's brain-computer many months to solve this problem. Even the adult's brain-computer may take a week to solve the rather simple problem of riding a bicycle. When obtained, this solution, or rather 'grid of experimental results', is stored in the memory for future use by simple interpolation.

By bringing together two diverse bodies of knowledge—computer technology and neurology—the author wrote a most stimulating book, containing material for much further thought.

A. H. Armstrong

SPECTRAL CASEWORK

Four Modern Ghosts

By Eric J. Dingwall and Trevor H. Hall. Pp. iii+8 plates. (London: Gerald Duckworth and Co., Ltd., 1958.) 15*s*. net.

THE first case concerns the repeated popping out of a book from a library shelf. In the authors' considered opinions the presence of a black nylon thread may have escaped the attention of the witnesses of the phenomenon. They then revive the late Harry Price's sensational story of how he visited an unnamed house and witnessed the most extraordinary séance ever vouchsafed a sceptical investigator. The living, breathing, talking figure of the little girl Rosalie materialized within a sealed room. The medium disappeared soon after, and the persons present have never been traced. The authors conclude, as have many others before them, that Harry Price, whose romancing propensities they exposed in a previous book, must have invented the whole episode. The third case is a typical poltergeist, with unexplained knockings and movements of objects at night, especially when two youths are about, and one member of the family said to have been caught by newspaper reporters in the act of throwing a book. The authors preserve "an attitude of suspended judgement". Finally they deal with bumpings, tremblings and noises in a house in Ousedale, and here they succeed in clearing the housemaid suspected of responsibility and placing the blame on subsidence due to subterranean water.

To quote the words the authors use of Harry Price, they may not have "advanced our knowledge of the supernatural in any way whatsoever", but they give a good display of professional zeal. The question looms large in their discussions whether their former collaborator, Mrs. Goldney, was once taken in by Harry Price. In reference to the Society for Psychical Research, they comment mildly in several places that, until recently, no discussion of the seismic theory of haunting noises has appeared in the Society's publications, but they quote an ancient letter to *The Times* describing the Society's methods of investigation as fit to "provide contempt in Bedlam itself". In an ingenious juxtaposition of sentences they say that "Mrs. Goldney became Organizing Secretary of the Society" but fail to mention that Dr. Dingwall himself was once its research officer.

The authors advance the theory that Harry Price, from lack of inventiveness, placed his imaginary séance with Rosalie in Brockley where years before he had attended some fake séances. They say they have discovered "correspondence which proved positively that Price has revealed that the séance was at Brockley", but though they quote extensively from all sorts of correspondence they give absolutely no details about this discovery. One suspects this lapse must have lost them several points of 'investigationmanship'.

D. J. West

RESEARCH ON FOOD

Advances in Food Research

Vol. 8. Edited by E. M. Mrak and G. F. Stewart. Pp. xii+437. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 12 dollars.

Processed Plant Protein Foodstuffs

Edited by Aaron M. Altschul. Pp. xv+955. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 26 dollars.

The Microbiology of Fish and Meat Curing Brines

Proceedings of the Second International Symposium on Food Microbiology held at Cambridge (United Kingdom) in April, 1957. Edited by Dr. B. P. Eddy. Pp. vi+336. (London: H.M. Stationery Office, 1958. Published for D.S.I.R.) 45*s*. net.

Bibliography of Food

A Select International Bibliography of Nutrition, Food and Beverage Technology and Distribution, 1936–56. By E. Alan Baker and D. J. Foskett. Pp. xii+331. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 63*s*.; 11 dollars.

Flavor Research and Food Acceptance

A Survey of the Scope of Flavor and Associated Research compiled from papers presented in a Series of Symposia given in 1956–1957. Pp. vi+391. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 10 dollars.

THE ever-increasing number of published papers on all aspects of science makes it more and more difficult for scientific workers to keep abreast of what is being discovered. The streets of London are to-day filled with complex machines designed to enable a man to move rapidly and comfortably from place to place, yet the net speed of movement is slower now than it was in the days of the hansom cab. In just the same way, the congestion of publications makes it as difficult to-day to be well learned in one's subject as it was in the earlier centuries of science.

There are several ways of dealing with the situation. To read all the published material is impossible; to digest the great fortnightly editions of *Chemical Abstracts* takes more time and determination than many of us can command; even to master the close-woven pages of the annual reviews is sometimes a heavy task. The editors of "Advances in Food Research" have chosen the more scholarly approach. They have selected six authors, three from the United States, two from England and one from Holland, and asked each to write a critical review. The result is an excellent book. G. W. Scott Blair discusses rheology in food research with all the mathematical erudition which we would expect for an article in such a volume, but also with philosophical urbanity which is equally to be welcomed. P. A. Raelofsen reviews the out-of-the-way corner of the fermentation industries concerned with the processing of cacao beans. A. C. Hulme deals with the biochemistry of dying organisms, namely, apples and pears. F. A. Lee and M. Milner contribute excellent articles, the first on the blanching of vegetables and the second on new methods to detect and eliminate insect-infested grain. The total impact of the book is to emphasize the axiom that the line between pure and applied science is a blurred one when good scientists write.

"Processsed Plant Protein Foodstuffs" is also an excellent compilation. With great thoroughness and in 955 pages the international team of thirty-eight authors has amassed a reference book of documented information on oil-seed meals of every sort as well as on by-products of milling, fermentation and much else. To leaven the lump, R. F. A. Dean has contributed from the Medical Research Council unit in Kampala, Uganda, an excellent and balanced review on the use of these vegetable proteins in human nutrition.

"The Microbiology of Fish and Meat Curing Brines" consists of thirty-eight papers, mostly quite short. They will be of interest to the people who attended the congress at which they were originally read. Scientists whose interests in biology are more general will be prepared to wait until the observations, facts, comments and doubts reported here are fitted into a more complete picture.

The "Bibliography of Food" is a most systematic affair, ranging widely from lists of grocers' journals to Sumner and Myrback's monograph on enzymes—unexpectedly entered under "nutrition: vitamins". The compilation of a bibliography, however, is a treacherous business even if it is a 'select' one. But though the authors do list Plimmer's historical tables of food composition and omit to mention the workaday ones of McCance and Widdowson, all in all they deserve our thanks for their efforts to codify the sources of twenty years of information on food.

"Flavor Research and Food Acceptance", fathered by no live editor but by an institution, Arthur D. Little Inc., is very good in parts, notably the excellent sections by L. M. Beidler and C. Pfaffmann on the physiology and psychology of taste, respectively. Other chapters are on a different level. For example, it appears that an agreeable aroma is important for the sale of petrol as well as soup. The book is a marriage of commerce and science, and the marriage is not an altogether happy one. MAGNUS PYKE

INFECTIOUS DISEASES

Die Infektionskrankheiten des Menschen und ihre Erreger

Herausgegeben von Prof. Dr. A. Grumbach und Prof. Dr. Kikuth. Band 1: Pp. xl+1–840. Band 2: Pp. iv+841–1702. (Stuttgart: Georg Thieme Verlag, 1958.) 198 D.M. (zwei banden).

THIS work is the product of the experience of Dr. Grumbach of the Institute of Hygiene, Zurich, and of Dr. Kikuth, the well-known pioneer in malaria and chemotherapy, assisted by a number of German, Swiss and other specialists. It is written from a novel point of view—to facilitate the understanding of the laboratory and scientific sides of infective disease by the clinician, and of the medical side by the biologist. It is not a laboratory manual in that details of technical procedures are largely omitted, and it is entirely bereft of illustrations, but throughout the book the clinical and therapeutic descriptions are intimately related to etiology; another title might have been "Clinical Microbiology".

The first part is occupied by a description of the general principles of the subject as a whole (such as virulence, epidemiology and immunity) and of the specific groups (bacteria, rickettsia, viruses, fungi, protozoa and helminths), followed by useful chapters on chemotherapy (by Klein), disinfection (by Roemer) and disinfestation (by Weyer). The second part forms three-quarters of the two volumes and is devoted to the individual infections. Each is considered under the following headings: signs and symptoms, morbid anatomy, infective agent, pathogenesis, epidemiology, diagnosis, treatment, prophylaxis and control. This uniform classification makes it easy for reference, while an up-to-date bibliography, at the end of each section, indicates original sources, methods, etc. The greatest attention is paid to the bacterial and virus diseases (about a thousand pages); the parasitic infections are considered in much less detail, and organisms of minor importance are omitted (such as *Sarcocystis*, *Pneumocystis*, *Trypanosoma rangeli*, *Isospora belli*, *Iodamoeba butschlii*). The book is clearly written and well produced, and is specially recommended to workers in temperate zones; it will undoubtedly form a standard text-book on the subject of microbiology. P. C. C. GARNHAM

CHEMICALS AND INSECTS

Methods of Testing Chemicals on Insects

Vol. 1. Edited by Harold H. Shepard. Pp. iv+356. (Minneapolis, Minn.: Burgess Publishing Company, 1958.) 40*s*.

THIS is the first volume of a work of which another one, or possibly two, further parts are projected. The preface says, "This manual is intended to describe methods used in studying any phase of the action of chemicals on insects", and this first volume is devoted to the more fundamental aspects of the subject and to general techniques. More specialized subjects, such as testing chemicals for wood impregnation, soil treatment, as repellents and acaricides, are reserved for the second volume.

The sixteen authors, thirteen American and three British, are mostly well known. Together they contribute fourteen chapters which may be given the following condensed titles: (1) cuticle surface; (2) cuticle penetration; (3) respiration; (4) electrophysiology; (5) circulation; (6) radioactive tracers; (7) resistance; (8) topical application and injection; (9) feeding; (10) dipping; (11) spraying surfaces; (12) dusting; (13) fumigation; (14) synergism. It will be noted that methods for testing space sprays, mosquito larvicides and systemic insecticides are not included.

The chapters vary greatly in length (from seven to one hundred and five pages) and in the detail with which the subjects are treated. It appears from the preface that the editor has had some difficulty in collecting the contributions. Perhaps this is why so little attempt seems to have been made to impose on the authors a greater uniformity of presentation. For example, in dealing with the actual methods the author may simply refer to the literature, give an outline description and refer to the literature for details, or give a full description down to the last particular. Furthermore, authors are clearly uncertain how much attention to give to the vital subject of standardizing and handling the test insects and to discussing the relationship between the insects and the insecticide under the test conditions. Some scarcely mention these subjects while others treat them at great length and refer to much literature which more properly belongs to other chapters.

The work invites comparison with "Techniques for Testing Insecticides" by J. R. Busvine already reviewed in *Nature* (182, 486; 1958). Criticisms may be made of Dr. Busvine's book, especially of some of the explanations and interpretations he gives of the experimental methods he describes, but it is a better balanced work and more logically planned. On the other hand, perhaps none of the chapters is as clear, accurate and complete as the best in the present book —for example, Chapters 8 and 11. The type is bold and the book is pleasantly produced. The index is extremely brief.

There is no doubt that many people engaged in testing insecticides will find this book useful and convenient as a reference work. But there is equally no doubt that the general planning of the book and the contents of some of the chapters could have been considerably better. The ideal reference work on this subject has still to be written. W. A. L. DAVID

In a practical determination of the errors of a system to which such an input is applied, computer techniques are very desirable. The design of analogue computers for such simulation studies is considered. The errors in autocorrelation measurements are studied, first with particular reference to signals that are random in the video range and later for signals which have first been demodulated from radio frequencies either by a linear or a square law detector.

The topic is exceedingly thoroughly treated by the author, and, although essentially of a mathematical nature, he has not failed to keep the essential engineering nature of the problem before him. R. A. KING

NOISE THEORY

Principles and Applications of Random Noise Theory

By Dr. Julius S. Bendat. Pp. xxi+431. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 88*s*. net.

NOW that electrical science has within its grasp a wide variety of instruments of ever-increasing sensitivity, it is imperative that the design of such instruments should be such that the information obtained from them should be as little as possible dependent on random external influences. This problem occurs again in the general field of communication where it is desired to identify some desired signal in the presence of some completely masking spurious signals. The available knowledge in these fields has been collated and amplified in this book by Dr. J. S. Bendat.

It is essentially a book for the advanced student in the field of noise investigations, although the introductory chapters do give a very clear review of the basic mathematical concepts on which all the theory is developed. Correlation functions are here defined and the special significance to the engineer of the exponential-cosine correlation function is very wisely stressed. Other important concepts included in this introductory section are power spectra and their relationship with correlation functions, and also sampling theorems.

The book develops with a fairly detailed study of probability theory; its applications to a number of random variable situations follow, well illustrated by a few simple engineering problems. As a final consideration, a situation outside that where the normal distribution holds is considered, namely, the case of the distribution of a noise envelope.

With this background, the ultimate object of the book becomes apparent in the next chapter. This is devoted to an investigation of the design of a network which will produce with any specified error some stated function of an input signal which has been degenerated with noise. This analysis is extremely general, being an extension of the pioneer work of Wiener to less restricted situations. The further problem of separating a desired signal from two received signals, both of which are degenerated by independent random signals, is also considered and illustrated by a deep problem on control.

The author now illustrates the wide applicability of the exponential-cosine autocorrelation function by a consideration of a number of varied practical systems in which it is applicable.

AVAILABLE ENERGY IN THERMODYNAMICS

La Thermodynamique et le Théorème de l'Énergie Utilisable

Par R. Marchal. Pp. xxx+208+7 planches. (Paris: Dunod, 1956.) 1580 francs.

IT would appear that the author of this book felt a mission to bring to the notice of engineers the concepts and theorems of available energy, which are too frequently ignored in engineering text-books. The chapter in which this subject is treated well repays close study, although it would be possible to improve on some of the methods of presentation. Unfortunately, the preceding five chapters, on the first and second laws and the properties of perfect gases, cannot be recommended as a good introduction to the later chapter.

In the preface the author sets himself against a course which, in attempting to be a monument of deductive logic, loses contact with reality, but he goes to the other extreme in failing too often to define his terms clearly. Failure to define 'heat' results in surprising confusion of thought in several places. In the presentation of the first law, system analysis is perfunctory and no mention is made of control surface analysis as such; this may account for a confusion between thermodynamic cycles undergone by systems and mechanical cycles of operation of engines. These confusions place severe obstacles in the way of students hoping to understand the later and more worth-while chapter on available energy.

Many will not agree with the author, a professor in the École Nationale Supérieure de l'Aéronautique, that the ease of their mathematical treatment justifies the early introduction of perfect gases, which receive undue prominence in the text. Nevertheless, their use permits the presentation of two very interesting charts showing the available energy (availability) in non-flow and steady-flow as a function of the temperature and pressure ratios of system and environment. The author does well to point out in a footnote that the chemist's uses of the functions F and G result as special cases from the engineer's more general study of availability functions, although the book does not deal with the analysis of combustion problems or chemical reactions. The last chapter, on the representation of fluid properties, contains a useful but brief treatment of characteristic functions.

While a study of the chapter on available energy may prove rewarding, the book cannot be recommended as a standard text on thermodynamics.

R. W. HAYWOOD

Social Class and Mental Illness

A Community Study. By Prof. August B. Hollingshead and Prof. Fredrick C. Redlich. Pp. xii+442. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 60*s*. net.

THIS book is the record of work done jointly between Prof. A. B. Hollingshead, who occupies the chair of sociology at Yale University, and Prof. F. C. Redlich, who is professor of psychiatry at Yale University School of Medicine.

As might be expected, the research is meticulous and explores a section of psychiatry which has been singularly neglected. Commencing with a history of the New Haven community and revealing interesting details of the earliest members, they then deal with the history of psychiatry there. This brings the book up to the present time and an examination of the problems they have set out to investigate. These are the different classes of society and the nature of the mental and nervous illnesses which are to be found associated with them, how the members of the different classes become patients and how their relatives react to the necessity for psychiatric treatment.

Strangely enough they find that the members of the wealthiest classes tend to be dissatisfied with themselves when they are ill, the middle classes have anxiety symptoms, and the lower class neurotics develop aches and pains. The very lowest class develops behaviour disorders rather than neuroses. Psychotics appear in greater numbers in the lower classes and this seems to be caused not by a downward drift in society but by something else, probably stress and strain, in the environment.

This book is well worth the study of psychiatrists interested in social factors, and it is to be hoped that future work along the same sort of lines will be undertaken in Great Britain. CLIFFORD ALLEN

Tupu-Tupu-Tupu

By Peter Krott. Translated from the German by Edward Fitzgerald. Pp. 232+25 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 21*s*. net.

THERE seems to be no limit to the extent man will go in his quest for new knowledge. During the past thirty years the unparalleled discoveries in natural science have been accompanied by investigations in natural history which are themselves tribute to man's curiosity, resource, persistence, patience and courage. Birds and the not-too-dangerous animals, for example, have been observed with such diligence and devotion that many new truths about animal behaviour have been revealed. To join the swelling ranks of this fine army of observers comes Peter Krott, an Austrian who made his home in northern Finland and Sweden and who became captivated by the study of that very dangerous animal, the wolverine, or glutton.

Despite incredible difficulties and much stupid and hostile opposition from so-called 'sportsmen', Krott secured the support of the Swedish Forestry Department to carry out systematic studies of an animal of which little was known other than that in northern mythology it was reputed to be the incarnation of the Devil. Krott showed that the mystery surrounding the wolverine was largely because it lived a much more secluded life than other beasts of prey, was avoided even by powerful animals like the bear and northern lynx because of its fighting abilities, was capable of considerable domestication if caught young, exhibited ferocious territorial behaviour and would not tolerate other wolverines of the same sex in the territory. The book is well written and the translation from the German owes much to Edward Fitzgerald; it contains some remarkable photographs.

Basic Physics

By Dr. A. R. Meetham. Pp. xi+144. (London and New York: Pergamon Press, 1957.) 21*s*. net.

DR. A. R. MEETHAM deserves praise for what is indeed a bold departure from the standard method of presentation of physics at the Advanced Level of the General Certificate of Education. He admits, in the preface to his book, that intending university students will need something more advanced, but for the average fifth- and sixth-form pupils many of whom have no intention of making their living by physics and for whom the Advanced Level is the end of their study of the subject, the large number of historical facts, methods, reasons and proofs which they have to memorize, Dr. Meetham maintains, only tend to obscure the basic physical principles. Hence "Basic Physics" is shorn of all these details, representing Advanced Level physics, with everything human, historical and experimental eliminated. Mathematics is not excluded, but is used mainly only to express symbolically the relationships between quantities, and mathematical proofs are deliberately avoided. A glance at the book is sufficient to see that Dr. Meetham knows what he is doing and why, and that his subject-matter is good, sound physics, clearly expressed and well arranged in a connected pattern. However, in many places it becomes so bare that it consists merely of a list of definitions and formulæ. It is an excellent book for sixth-form revision and perhaps also for university scholarship candidates. It stimulates thought by its provocative attitude of expression and approach, and its frank re-statement of the fundamental processes of physics, but it is not an Advanced Level text-book of physics. S. WEINTROUB

Communications and Electronics Buyers' Guide, Who's Who and Reference Book, 1958–9 Edition

Edited by C. C. Gee, with the assistance of D. W. Dwyer. Pp. 360+156. (London: Heywood and Co., Ltd., 1958.) 105*s*.

THIS is a well-produced and well-edited book, large in bulk and price, but full of information likely to be of value to all engaged in electronic work. It covers the whole of electronics, and by including allied industries it is enabled to cover acoustics, materials, etc. The bias is strongly towards what it calls "capital-equipment electronics", and the consumer sector of the industry is only briefly covered since there are other sources of data on this.

The Buyers' Guide Section has several alphabetical indexes, and the first of these—the classified index of products—is probably the most important. Under each product are given the names of the firms manufacturing it. The Who's Who Section may be of some value, but there are better works of this kind. The Reference Section is certainly valuable; the product surveys are probably the most useful part of the whole book. In them, all known products under a heading are tabulated, together with their salient performance characteristics. The book vividly portrays the amazing recent growth of a major industry.

D. G. TUCKER

ORIGIN OF THE RADIATION NEAR THE EARTH DISCOVERED BY MEANS OF SATELLITES

By Prof. T. GOLD
Harvard College Observatory, Cambridge, Mass.

INFORMATION has been obtained, both by Van Allen and his group in the United States[1] and by Russian workers with satellites[2], showing the presence of an intense flux of penetrating particles over most of or all regions of the Earth at heights in excess of 600 km. The most detailed information to date comes from Van Allen and his group, and was obtained with the aid of the *Explorer* 4. Neither the spectrum nor the identity of the particles has yet been established; but it is clear that one is here concerned with a very major phenomenon, either in the outer zones of the Earth's magnetic field or indeed in the whole of our region of the solar system. The observations indicate an increase in the flux with height, and the *Explorer* data that go up to a height of 2,200 km. still showed the high rate of increase there. The energy-range of the charged particles concerned seems to extend from perhaps several tens of keV. to several tens of MeV. Intensities of the order of a few hundred particles per steradian per cm.^{2} per sec. capable of penetrating the shielding of 2·5 gm. per cm.^{2} have been recorded. At the low-energy end of the range there appear to be fluxes of the order of 10^6 or 10^7 particles per cm.^{2} per sec. per steradian.

In addition to the satellite observations, there exist the auroral observations indicating high fluxes and a very steep energy spectrum in an actual aurora[3,4]. As many as 10^8 electrons per cm.^{2} per sec. per steradian with energies of the order of a few tens of keV. are thought to exist in actual auroral formations, and to be responsible for much of the light emitted there.

For any of the energies concerned, and for either protons or electrons, it would be true that the Larmor radii in the Earth's magnetic field are very small compared with the radius of the Earth; and it is this fact that allows one to discuss all this flux under one heading and without a more complete knowledge of identity or spectrum. For example, a 10-MeV. proton at a height of 3,000 km. above the equator would have a radius of gyration of approximately 3 km.

It is very tempting to think of the auroral flux and of that observed at lower latitudes and greater heights by the *Explorer* as being part of the same phenomenon. On that basis one can give a lower limit to the rate at which energy must be fed into the whole region from an estimate of the mean auroral brightness and the efficiency of light production. Cosmic-ray secondaries have been discussed as a possible source for this particle flux[5], and although neutrons scattered from the atmosphere and decaying there would provide a means of supplying such a flux, the total energy obtainable falls short by a factor of 10,000 for supplying the mean auroral light. The auroral flux can thus not be thought of as being a flux of stored particles in captured orbits in the Earth's field produced by cosmic rays and diverted through the magnetic disturbance into the auroral atmospheric zones. Some other and enormously more energetic source of supply for this flux must be found.

To clarify the requirement for the injection mechanism, let us consider first the range of orbits possessed by these particles. A charged particle in this energy-range liberated at some height above the atmosphere on the equator would in general spiral around the lines of force and thus proceed to a higher latitude and lower height (Fig 1). It would thus travel into a converging magnetic field and, as is well known, the pitch angle of the spiral orbit (that is, the angle between the trajectory and the magnetic field) would become larger and reach 90° at a particular point. In effect, the particles would be reflected and travel with the guiding centre closely following the line of force to the corresponding point in the other hemisphere. The position of the reflexion point, or the field-strength that occurs there, is defined by the field-strength and pitch angle of a particle at any other point of its trajectory through the good approximation that the magnetic moment of the orbiting particle must remain constant. The reflexion point is then given by the place where the field-strength reaches the value $B = B_0/\sin^2 \psi_0$, where B_0 is the field-strength at some other point on the trajectory and ψ_0 is the pitch-angle of this trajectory there.

The observed flux must thus be due to particles that oscillate quickly in spiralling orbits between the two hemispheres with a distribution in latitude related to the distribution of pitch angles.

This rapid oscillation, with periods of the order of a fraction of a second to seconds, is, however, not the only motion taking place. For the dipole-like field, the field-strength has a gradient not only along the lines of force but also across them. A slow drift motion of spiralling particles then occurs in a direction

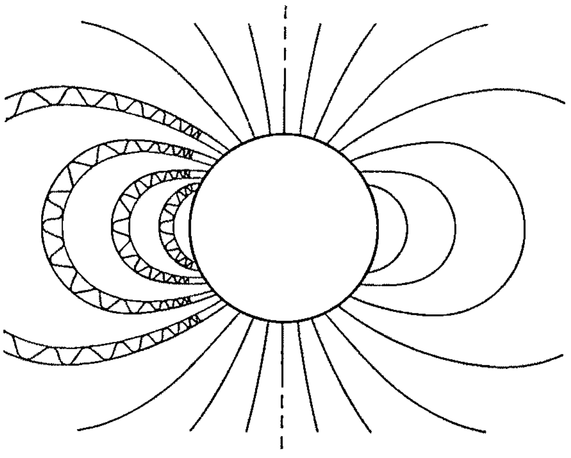

Fig. 1. Lines of the Earth's field and a schematic representation of some spiral orbits of charged particles showing the oscillation between the two hemispheres, and the reflexion in the converging fields

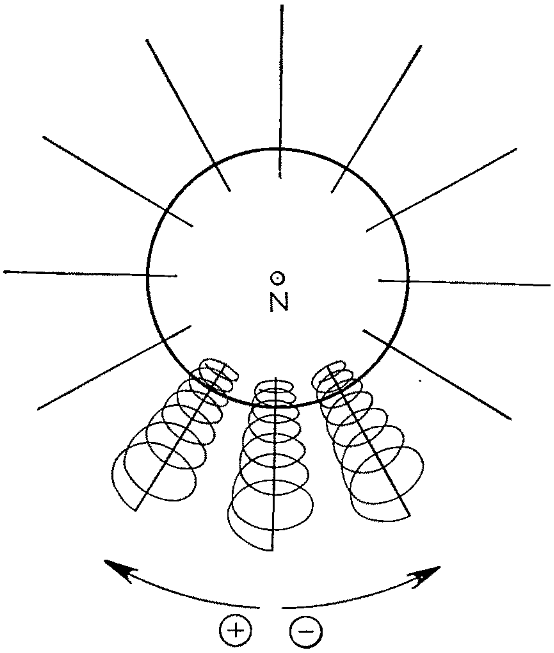

Fig. 2. Captive particle orbits, schematically, as seen from above the North Pole. Electrons will drift slowly eastwards, positive ions westwards

normal to the field and normal to its gradient, and for a perfect dipole field this would be a motion in longitude. This migration would take the particles once around the Earth in a time that depends upon the particle energy and the height of the orbit, but would generally be between a few minutes and a few hours. For a perfect dipole field and in the absence of any scattering by gas molecules, this would be the complete description of the types of motion that can occur.

The actual field of the Earth is very substantially different from a dipole field, as, for example, there are large regions on the surface where the field-strength differs by as much as 20 per cent from that which would result from the otherwise best-fitting dipole. The non-dipole parts of the field now provide a further type of drift motion of the particles, and, as there are gradients of the field in longitude, there will be drift motions in height. The individual orbits then become very complicated, and will in effect represent a diffusion of the flux in height.

In addition to the non-dipole, permanent features of the field, there are the magnetic variations impressed from outside. These also will make for complicated orbits that effectively diffuse the flux. As the non-dipole components of internal origin diminish faster with height than the dipole field, while the proportion of the field-strength due to the externally impressed variations must increase with height, the external effects will dominate above a certain level. Also the type of orbit changes that can be effected with a time-dependent field may be significantly different from the drift motion in a steady field.

There are then the four different modes of motion of particles, each with a different time-scale : (*a*) the gyration in the field ; (*b*) the quick north–south oscillation along lines of force ; (*c*) the drift in longitude ; (*d*) the drift and diffusion in height. Of these motions, it is only the last the time-scale of which cannot easily be calculated ; but it is certain that this motion is much slower than the drift in longitude. As molecular collisions are rare, leading to time-scales of many years[5] for the flux stored in a perfect dipole field, it is also most likely that the drift in height is the main agency for the removal of particles from a given zone. An upward drift would result in a loss of particles from the vicinity of the Earth, while a downward drift will result in their dissipation in the atmosphere.

For all but the highest particle energies, the magnetic moment of the orbiting charge must remain constant throughout the motion. The migration in the field will therefore be limited for any particle to the region in which the field-strength is less than $B_0/\sin^2 \psi_0$, where B_0 and ψ_0 are the field-strength and pitch-angle, respectively, at some point along the orbit. Of a particle flux injected at a greater height only a certain proportion, namely, that injected with steep enough pitch-angles, will be able to reach the lower level. The equatorial regions are therefore accessible to a larger proportion of the particles than the higher latitudes where the field-strength at a given height is greater.

The migration of particles by molecular collisions is an insignificant process, as many more collisions would be required to cause a significant displacement than to dissipate the particle energy. But this does not mean that collisions are unimportant, for in a single collision the pitch angle of a particle may be changed from a flat to a steep one, and the region accessible to further migration will then be greatly increased.

For any flux with particle energies above some tens of MeV. the rule of the conservation of the magnetic moment would not apply accurately any longer, and the vertical migration would therefore not be subject to the same strict limitations.

With these properties of the flux in mind, let us now consider the consequences that would result from a supply of such particles initially isotropically at a point at, say, 5 Earth's radii above the equator. Of the isotropic flux, a small fraction would be travelling very nearly along the lines of force, and that fraction would be able to reach immediately to high latitudes and low heights. All the flux within a certain small angle to the lines of force would thus reach into the atmosphere and be dissipated there. The immediate effect would thus occur where the particular lines of force on to which the particles were supplied dip into the atmosphere, and an auroral luminescence lighting up these lines can be expected. The flux will thus suffer a change, in that the steepest-pitched particles are removed. Also a spread in longitude will set in through the action of the drift in the dipole field, and this spread will be fastest for the highest energy particles. Particles will thus be supplied around the entire belt of magnetic latitude, but will not dip quite so deep into the atmosphere. One would thus expect an auroral luminescence at a higher level, stretching out around the entire auroral bands.

For a perfect dipole field concentric with the Earth the drift motion in longitude would merely result in a steady weakening of the aurora along the belt in the direction of the drift (eastward for electrons), as the steeper pitched particles get removed. But in the actual case where the best-fitting dipole is significantly off centre, and where the non-dipole components are significant, this variation in longitude must be expected to be quite different. At some particular longitudes on the Earth where the field at a given height is weakest the reflexion points of particles will be lowest, and therefore a flux will penetrate into the atmosphere there that had escaped dissipation at other longitudes. Such places in the field ought, therefore, to show auroræ always following an injection of particles and an aurora at any other longitude. The detailed dependence upon longitude can also reveal the sign of the charges of the particles responsible, by the sense of the longitude drift motion that would give the observed effects. Thus a local minimum in the field ought to have the greater auroral activity generally to the west if electrons are responsible.

If the original supplied flux was isotropic, then only a small fraction, of the order of 1/1000, will have been in steep-pitched auroral orbits. All the remainder will drift around the Earth and will gradually be distributed in height through the action of the inhomogeneities and the variations of the field. This distribution in height will happen comparatively quickly down to levels where the field-strength is such that no change of magnetic moment of a particle is required to reach there. Thus the steepest-pitched particles of the original flux that are left over will be the ones to migrate to the lowest levels, and they will be able to reach such field-strengths as they reached above the auroral zones without striking the atmosphere.

Without a detailed understanding of the complicated orbits leading to the diffusion in the field, the following general statements can still be made. First, the flux will get weaker as one goes away from the place where it was supplied. Secondly, time variations in the supply of particles to the system will be smoothed out with time constants given by the diffusion time that occurs between the point of supply and the point observed. Such diffusion times may well be a matter of weeks or months for the inner zones that have so far been observed. The flux that has suffered the longest migration in the field can be expected to show the least time variations and to show a tendency for the lines of constant intensity to follow not the field lines but the lines of constant field-strength. A shallow maximum of a rather steady flux above the equator is therefore to be expected, and it seems to be found in Van Allen's data. The lower regions of this zone have to be identified with the auroral belts, while above the equator the zone would be at a height of 4–6 Earth's radii. This zone has often been suggested as the supply route for auroral particles. In the present discussion I essentially add only the consideration of the fate of all those particles, several hundred or a thousand times as many for the case of isotropic injection, that travel in insufficiently steep-pitched orbits to reach down to the atmosphere and cause an aurora before being reflected in the converging field.

If observations of the particle flux are extended to greater heights above the equator one would therefore expect a continuation of the increase with height up to perhaps 5 radii, with a marked increase in variability and dependence upon the magnetic storm phenomena. The amplitude of the variations will, however, remain much smaller than those of the auroral flux, for even there the majority of particles will be in stored orbits that do not dip into the atmosphere. Beyond this height the flux will depend on the method of supply from the Sun, known to be highly variable.

If the phenomenon is thus interpreted, then the process of supply is intimately related to the magnetic-storm effects. It is thought that solar outbursts propel gas masses to velocities of the order of 1,000 km./sec., and that a magnetic storm phenomenon results when such gas masses strike the magnetic field of the Earth. On the scale of the phenomenon and with the degree of ionization involved, there is no doubt that the conductivity is high enough to ensure that the magnetic configuration is the one determined by the flow that has taken place. Thus, if a cloud of material expands from the solar surface, then any lines of force that it originally possessed linking it to the solar surface must be drawn out and carried along into all the spaces reached by the cloud. Unless the initial field in the gas was zero, such a cloud will thus remain magnetically connected to the solar surface. In order to discuss what particle fluxes may be present in the cloud of energies higher than those merely corresponding to its bulk motion, one has to consider what fluxes may be available generally on the solar surface; for any such particles will be able to move freely in their spiral orbits along all the lines of force drawn out by the cloud, and they will continue to populate all the regions reached by the cloud.

It is known that great solar flare outbursts can produce an intense flux of cosmic-ray particles at energies reaching to more than 10 BeV. Similar types of phenomena, but on a much smaller scale, seem to occur very frequently on the solar surface, and perhaps even continuously. Thus a supply of particles accelerated to energies much smaller than 10 BeV., but very much above thermal speeds, may well be constantly available on the solar surface and therefore may always populate all the lines of force that have been dragged elsewhere by outbursts of gas. Any magnetic-storm cloud approaching the Earth may thus have a high particle flux in it.

The speed of travel of the cloud itself determines the magnetic configurations, because it contains the necessary momentum. The high-speed particles possessing a total momentum insufficient to make the major changes of the fields can only come here together with the bulk of the gas clouds, and there is then no conflict in the observation that particles of MeV. energies appear here after time delays corresponding to velocities of only a few hundred or a thousand kilometres per second (proton energies of the order of 1 keV.).

For a static configuration of the Earth's field, the captive particle orbits are, of course, in a region that cannot be reached by such particles coming from outside. Particles may, nevertheless, be placed there in the course of a disturbance of the field configuration, and the magnetic-storm phenomena known to be associated with auroræ need, therefore, to be discussed.

The magnetic observations on the ground during a magnetic storm indicate that the phenomenon is very variable in time and also in position. Two stations at the same latitude but separated in longitude by as little as 1,000 km. show markedly different fluctuations. The sources of disturbance up above must thus be thought of as being very patchy, and indeed the same conclusion results from the appearance of the auroræ. Such a small-scale patchiness cannot possibly be attributed to the cloud that has come here from the Sun, but must be a phenomenon set up in the vicinity of the Earth by an instability of the flow of the solar stream around the Earth's field. Thus, if at a distance of, say, 5 Earth's radii there was not in existence a smooth surface dividing the terrestrial from the solar field, but a surface containing many fine corrugations or tongues with the scale of these variations not greater than a few hundred km., then this pattern would account for both the scale and the magnitude of magnetic disturbances on the ground.

For the small-scale features of this pattern, it would no longer be true to say that the dissipation of electric currents responsible for the fields can be ignored, and indeed such dissipation times may well be of the order of half an hour, which is the speed of many of the fluctuation phenomena observed. In that case, fast particles spiralling around the lines of one field which is decaying can be transferred to the lines of force of the other field which is being established in that space. A penetrating tongue of solar field can thus shed its particles into the terrestrial field as dissipation occurs.

The transfer of fast particles from lines of force of the solar field to the terrestrial one may also occur in a manner not involving any dissipative changes of magnetic fields. Shock waves in magnetized conducting gases are thought to develop a shock front at least narrow enough to be comparable with the ion radius of gyration in the magnetic field at thermal speeds. Particles of much higher than thermal speeds will therefore traverse such waves. At the instant when it is a shock front that divides the solar from the terrestrial gas, the fast particles are moving in fields that change substantially in distances short compared with their radius of gyration, and they will therefore not remain effectively attached to lines of force but distribute themselves to both sides of the wave. It is therefore to be expected that fast particles will appear in the Earth's field in orbits into which they could not have been placed without the magnetohydrodynamic effects associated with magnetic storms.

Van Allen has reported recently[6] that an increase in the flux of fast particles, as counted in the *Explorer* satellites, has been observed following a magnetic storm. R. R. Brown has observed[7] an excess flux of what may be interpreted as secondary X-rays during magnetic disturbances at balloon altitudes and at latitudes well below the auroral zone. As this is most likely a secondary phenomenon of the Van Allen flux higher up, it also suggests the dependence upon magnetic disturbance.

Further experimentation should be able to clarify the situation considerably. It should be possible to show, for example, whether the time variations become indeed greater at greater heights and higher latitudes. Magnetometer observations should indicate whether at distances of the order of 5 Earth's radii the field structure is frequently patchy. If the present considerations are correct, radiation measurements at such heights should usually show a slow decrease with height above the injection region, while occasionally, during a magnetic storm, a substantial increase should occur there. Rockets flown to greater distances from the Earth should be able to signal the magnetic and radiation conditions when they are enveloped in a magnetic storm cloud.

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GEOPHYSICAL EFFECTS ASSOCIATED WITH HIGH-ALTITUDE EXPLOSIONS

By Dr. P. J. KELLOGG, Prof. E. P. NEY and Prof. J. R. WINCKLER
University of Minnesota

THE purpose of this communication is to indicate some geophysical effects which one would expect to be associated with high-altitude explosions of nuclear weapons or high-altitude chemical explosions. In addition to outlining the effects which one would anticipate seeing concurrent with high-altitude explosions, we will attempt to discuss two experiments which seem to bear on these problems: one was the Johnston Island nuclear explosion which was observed in some detail, geophysically, from the Apia Magnetic Observatory, and the other experiment is the recently reported high-altitude grenade shot at Woomera, Australia, which also seemed to be accompanied by geophysical effects.

The discovery by Van Allen and his collaborators at Iowa of the intense radiation belt surrounding the Earth has made it clear that stable trapped orbits of particles in the magnetic field of the Earth do in fact occur. We propose to discuss here the effects which accompany the release of these trapped Van Allen particles, as well as effects expected to be associated with the injection of additional particles from a nuclear explosion. Since the geometry of the trapping field determines the sort of effects to be expected, we will first discuss very briefly this geometry as it relates to our problem. Following this, we will describe effects characteristic of a nuclear explosion at high altitude, and finally, those to be expected from a large chemical explosion, also carried out at high altitude.

It is now quite generally recognized that the tubes of magnetic force surrounding the Earth act as a natural mirror, in which charged particles undergo helical paths oscillating between the northern hemisphere and the conjugate point in the tube of force in the southern hemisphere. The trajectories of these particles are determined by the pitch angles with which the particles pass the equatorial plane, and a given particle is reflected at that point in the field at which the trajectory becomes perpendicular to the magnetic line of force. With a perfectly symmetrical field, and in the absence of gas in which energy would be lost, the particles would oscillate between the northern and southern hemispheres indefinitely. The presence of gas in which loss of energy can occur at the lower altitudes causes the particles to have a finite life-time in this motion between hemispheres. Because, for reasonable energies, the radius of curvature is small compared to the radius of the Earth, the particles oscillate back and forth almost along a given magnetic line of force. For example, for a 1-MeV. electron, the radius of curvature would be approximately one-tenth of a mile near the surface of the Earth. Because the magnetic field is stronger at small radii than at large, in addition to the oscillating motion from northern to southern hemisphere, the orbits of the particles precess at right angles to a radius vector and constitute a ring current because of this precession. For example, for a tube of force at the equator near the Earth's surface, the precession of the orbit around the Earth would occur in approximately one hour. Although the exact number of particles present in the trapped radiation is not at present known, one can set an upper limit to the total energy of particles because of the known fact that the external portion of the Earth's magnetic field constitutes less than 1 per cent of the field measured at the surface. This upper limit of the energy of trapped particles in the Van Allen radiation is approximately 10^{27} MeV., or about 1,000 moles of trapped 1-MeV. particles. This limit does not depend on whether the particles are positive or negative, since negative particles precess to the east and positive to the west, and both constitute an effective ring current producing a magnetic field in the same direction at the surface of the Earth.

Finally, because of the inhomogeneities in the field, and because of the diamagnetism of the plasma gas, particles injected at a given point will tend to be distributed radially in a manner which is not easy to calculate. It is believed that this trapped radiation is of natural origin. The sources of replenishing it must be: (1) streams of solar gas; (2) neutron albedo from cosmic rays; (3) debris from high-altitude atomic explosions. All three of these sources must certainly contribute to the radiation, but it is not clear as yet which source is most important throughout the various ranges of energy involved.

The geometry of the tubes of force is such that the release of trapped radiation from the radiation belt would, qualitatively at least, give a very nice description of the auroral phenomena. Because of this, it seems to us to be quite crucial to test the hypothesis that Van Allen radiation, when released, can produce auroræ. This might be accomplished by high-altitude detonations designed to release the natural trapped radiation. Most calculations seem to indicate that the density of trapped radiation would be highest in those tubes of force which enter the Earth at approximately the latitude of the auroral zone. It is even possible that at certain times the density of trapped particles in these tubes of force is determined by the diamagnetism of the plasma gas, and that these tubes of force can only be filled to the point at which this demagnetization makes the tube unstable. This condition of instability will occur at a somewhat smaller density of particles than that at which the energy density of particles is equal to the energy density in the Earth's magnetic field. For an auroral tube of force reaching a radial distance of approximately 4 Earth's radii and entering the Earth at a latitude of 60°, this critical maximum energy density of particles would be approximately 10^{-6} ergs/cm.^{3}. If the particles consisted, say, of 1-MeV. electrons, the density would then be 1 particle cm.^{3}. It should be noted that this limit is in agreement with that derived from the condition that the particles cannot contribute more than about 1 per cent to the field at the surface of the Earth. That it should be possible to release this trapped radiation by explosive means now at hand can be seen from the following argument.

Since the energy density of particles cannot exceed the energy density in the Earth's field, an explosion in which an appreciable fraction of the stored energy in the Earth's magnetic field is dissipated in kinetic energy should allow the distortion of the field to the extent that particles may be released. The energy which is stored in the magnetic field of the Earth external to the surface is 10^{25} ergs. This corresponds to the explosive energy of a 200-megaton atomic weapon. Since only a very small fraction of the total energy stored in the field need be supplied in a conducting plasma, it is clear that a very much smaller explosion than 200 megatons would produce geomagnetic and geophysical effects. In an explosion, an appreciable fraction of the gas involved is ionized, and therefore constitutes a conducting plasma. If such a conducting plasma with kinetic energy is released in the region of the *E*- or *F*-layer, the plasma will be trapped in the lines of force of the magnetic field and distort this magnetic field into a large bubble. Part of the energy of the bubble should then be propagated as an Alfvén wave along the tube of force, going from one hemisphere to the other. The initial effect of the explosion with respect to the trapped radiation would be that those particles with pitch angles which became flat in the vicinity of the magnetic bubble would no longer be reflected and would be released from the trapped radiation field. Since the particles spend most of their time at the regions of reflexion, a relatively large number of particles would be released from the local region by such a plasma explosion. It should be pointed out that this explosion must be carried out at a high enough altitude to enable the kinetic energy of the explosion to be converted into distortion of the magnetic field through the interaction of the plasma and the magnetic lines of force, and that collisions with residual gas of the atmosphere do not dissipate this kinetic energy in heat. For these conditions, a high-altitude nuclear explosion would be ideal. We shall see shortly that such a high-altitude explosion, however, injects so many high-energy beta-decay electrons that the effects of releasing the trapped radiation would be obscured by the injection of radioactive particles from the atomic debris.

The velocity of the bomb-injected particles is on the average greater than the velocity of the Alfvén wave, and the injected particles will therefore reach the conjugate point before the Alfvén wave can release the natural trapped radiation.

In any high-altitude explosion, in which an appreciable amount of energy is coupled between the conducting plasma and the magnetic field, one would expect to see the following geomagnetic effects:

(1) The production of auroræ at the region of explosion and also at the conjugate point in the opposite hemisphere.

(2) Magnetic disturbances at the surface produced by the primary effects of the flowing charges in the ionosphere, and possibly by secondary effects caused by the release of additional particles as the magnetic

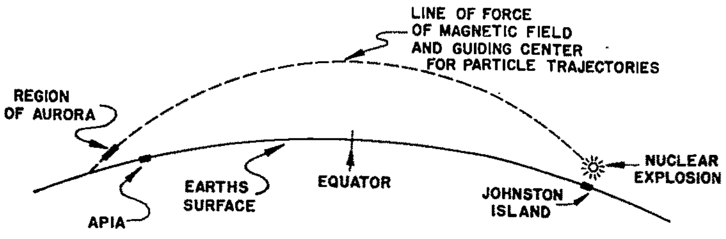
LINE OF FORCE OF MAGNETIC FIELD AND GUIDING CENTER FOR PARTICLE TRAJECTORIES
REGION OF AURORA
NUCLEAR EXPLOSION
EARTHS SURFACE
EQUATOR
JOHNSTON ISLAND
APIA

Fig. 1. Geometry of the Johnston Island nuclear explosion

field of the Earth becomes disturbed from the loss of the Van Allen radiation initially released.

(3) The propagation of an Alfvén wave, produced by the motion of the bubble along the lines of force. The Alfvén wave in this case may be thought of as a string wave in which the tension in the string is the tension in the lines of force, and the mass per unit length of the string is represented by the mass density of ionized particles which will be frozen to the line of force.

(4) Ionospheric radio effects. Because of the ionization produced by the released particles, which may have ranges up to several grams per square centimetre, there should be pronounced changes in the ionosphere, as evidenced by changes in the critical frequency of ionosonde soundings at both ends of the line of force.

(5) The presence in the upper atmosphere of the released radiation. This radiation could perhaps be studied from very high-altitude balloons, since the trapped radiation, once disturbed in pitch angle and allowed to penetrate down into the atmosphere, may have ranges in excess of several grams per square centimetre and could be detected at altitudes of 140,000–150,000 ft. by high-flying balloons. The bremsstrahlung from electrons stopped at very high altitude can be observed from balloons at 70,000–100,000 ft.

(6) The production of an artificial whistler by the propagation in the whistler mode of energy along the tube of force. This could perhaps be detected by the reception of audio electromagnetic waves at both ends of the tube of force.

(7) The effects can be used to locate magnetic conjugate points precisely.

Of the effects listed, we believe that the study of a 'point source' aurora is perhaps the most interesting, and an explosion properly carried out should be able to settle the question of whether auroræ can be produced by release of trapped radiation.

We shall now discuss the differences between nuclear explosions and those produced by chemical explosions in the *E*- or *F*-layer.

The Nuclear Explosion at Johnston Island

It has recently been reported in *Nature*[1] that at the time of the Johnston Island nuclear explosion geomagnetic disturbances were observed at the Magnetic Observatory at Apia; including visible auroræ, radio fadeouts, and a quite unusual magnetic storm lasting for several hours. We believe that the effects observed at Apia are in very good agreement with those expected from the injection of charged particles by the nuclear explosion at Johnston Island, rather than by the release of trapped radiation already present in that tube of force. The fact that the Apia observations were due to the Johnston Island explosion is indicated by the almost exact coincidence in time of the events and by the fact that such effects at low latitude as those observed at Apia on this occasion are extremely rare, only one previous case having been observed at this station. The time of the Johnston Island explosion was given as 12.52 a.m. Hawaii time[2], observed by an airline pilot flying over Hawaii who noted the nuclear explosion. This is 10.52 G.M.T., and the first observation of geomagnetic effects at Apia occurred at 10.51 G.M.T., August 1, 1958. The auroral display was observed in the west and south-west directions from Apia, and we have tried to calculate the impact zone of particles arriving in the vicinity of Apia along a line of force intersecting the northern hemisphere at 100 miles above Johnston Island. Fig. 1 shows a cross-section of the Earth showing the line of force along which the Johnston Island particles would be propagated. The thick line shows the region in which the particles would enter the atmosphere near Apia, and would produce auroræ. The altitude of the nuclear explosion is assumed to have been 100 miles—the altitude reported in newspaper accounts. The explosion must have occurred higher than 70 miles in order to be seen line-of-sight from Hawaii. The altitude at which the explosion occurs is that altitude at which flat pitch angles can occur (that is, orbit perpendicular to the line of force), and in fact flat pitch angles and reflexion cannot occur at a higher altitude than the altitude of the explosion. Steeper pitch angles, of course, can occur, and these will correspond to particles which penetrate deeper into the atmosphere at the other end of the line of force. At the atmospheric densities encountered at 100 miles altitude, the life-time of a 1-MeV. electron for loss of energy is approximately 20 sec. The easterly precession of the electrons, therefore, can only occur in a time corresponding to this life-time for loss of energy of the injected particles. The particles which will be propagated along the tube of force will be the beta-particles from the radioactive decay of fission or fusion products, depending on the nature of the bomb. These will be electrons and a few positrons in the 1-MeV. energy-range, and because the initial period of an atomic explosion is the most active one, the duration of the aurora will reflect the radioactivity of the products of the explosion. We believe that the five-minute duration of the aurora is a reflexion of this radioactivity rather than a life-time associated with the transmission or trapping of the particles.

Fig. 2 shows a plot of the expected impact area of the particles from the explosion, and the area in which the aurora was actually observed from Apia. The agreement is quite good, but the observed aurora seems to be north-west of the place expected from geomagnetic considerations. In order to calculate the geomagnetic conjugate point, we have used the position of the cosmic-ray equator, believing that it indicates best the direction of the tube of force. The disagreement between the calculated and observed impact areas may reflect uncertainty in our knowledge of the Earth's magnetic field, but might also indicate that the explosion, instead of occurring directly over Johnston Island, occurred somewhat to the south-west. Since the position of the impact zone agrees so well with the calculated position, one must inquire whether those particles arriving at Apia were released from the tube of force or injected by the atomic bomb. We have previously seen that

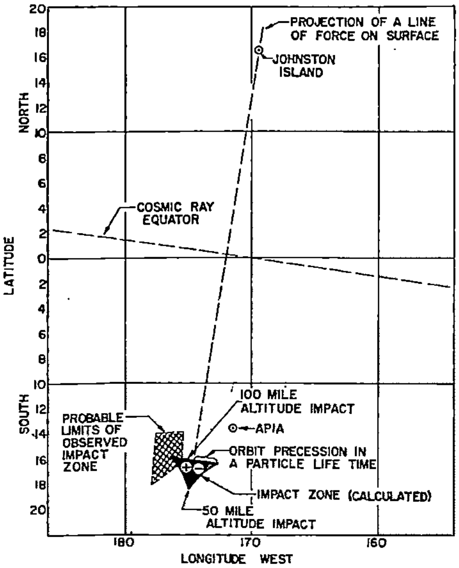

Fig. 2. Predicted and observed impact zones for the Johnston Island nuclear explosion. + and − refer to impact zones for positive and negative particles respectively

the total trapped radiation in the Earth's field represents perhaps 1,000 moles of particles. Because of the beta-decay following fission, approximately 5–10 moles of particles may be injected by an atomic weapon for each mole of fissionable material used. To get an idea of the order of magnitude of the injected *vs.* released particles, one might consider an explosion large enough to produce a kinetic energy equal to the Earth's magnetic field. This would presumably release all the trapped Van Allen particles, but it would in fact inject approximately 25,000 moles of beta-decay electrons, an order of magnitude more than the number of trapped particles already there. Since in the Johnston Island event we are considering a tube of force which reaches an altitude of only 400 miles at the equator, it cannot contain Van Allen radiation. The Iowa group finds the lower edge of the radiation belt at 1,000 km. It is quite clear in this case that many more particles will be injected than will be released, and that the auroral effects reflect these injected particles.

Chemical Explosions at High Altitudes

A recent *IGY Bulletin*[3] has reported observation of a luminescent cloud lasting three to four minutes following the explosion of a high-altitude sound-ranging grenade exploded at about 75 miles altitude. It seems possible to us that this luminescence could be produced by the release of naturally occurring Van Allen radiation. The rocket experiment was carried out at Woomera, Australia, at the end of a tube of force known to be populated with natural radiation. For an ideal experiment, with a chemical explosion at high altitude, one would attempt to carry out the explosion above 100 miles, and preferably at about 200 miles, in the *F*-layer of the ionosphere. It would also be desirable to have the ionization in the explosion as high as possible. Perhaps the addition of easily ionized material could increase the ionization in the chemical explosion. In the chemical explosion, however, the aurora observed, particularly at the opposite end of the tube of force, should be a definite proof of the possibility of its production by release of natural radiation. The detonation of a chemical weapon does not involve the problem of injection of charged particles from a nuclear bomb, but does suffer from the lower ionization in the chemical explosion. We feel that the detonation of approximately a ton of chemical explosive at 200 miles would produce a crucial test of this point.

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[1] Cullington, A. L., *Nature*, **182**, 1365 (1958). See also Fowler, P. H., and Waddington, C. J., *ibid.*, **182**, 1728 (1958).

[2] *New York Times*, Aug. 2, 1 : 5 (1958).

[3] *IGY Bulletin*, No. 18 (December 1958).

SPACE RESEARCH

By Dr. R. L. F. BOYD
Department of Physics, University College, London

THERE has probably never been a more rapid and far-reaching revolution in scientific technique than has been brought about by the advent of space-probing rockets. Between the end of the Second World War and the start of the International Geophysical Year more than one hundred upper atmosphere rockets were launched and a great deal was learnt, both about those regions and about the solar spectrum. In this period many techniques were developed which have been employed with even greater success in more than twice that number of rockets launched during the International Geophysical Year. With the use of geophysical rockets by the Russians, and especially of *Aerobee-Hi* by the Americans, the region between 100 and 300 km. above the Earth's surface has been explored with some thoroughness for the first time. At Churchill—in the auroral zone—and by launchings from a great variety of places, results have been obtained on the variations of many quantities with time of day, season and latitude. Most of the rockets fired had a useful life of only a few minutes, but this International Geophysical Year will be remembered also for the first launchings of artificial Earth satellites which made it possible to obtain world-wide coverage of the regions above 200 km. for weeks on end. During this time eight instrumented satellites have been launched and at least fifteen distinct objects have been placed into orbit around the Earth. In operation 'Farside', a multi-stage rocket launched from a balloon reached a height of 4,000 km.; more recently the 'Pioneer' Moon shots penetrated to more than 100,000 km., while the recent Russian space probe passed close to the Moon and entered a solar orbit.

On a more modest scale, in Britain, the International Geophysical Year has seen the successful initiation of the Royal Society - Ministry of Supply research programme using *Skylark*, and the first launching of *Black Knight*—a vehicle with great potentialities should it eventually become available for pure scientific research.

With the feasibility of direct experimental observation of the outer fringe of the Earth's atmosphere and of the nature and density of the corpuscular and electromagnetic radiation in the space beyond amply demonstrated, it was appropriate that a discussion of "Space Research" should be arranged by the Royal Society. In planning this two-day discussion, which was held on November 12 and 13, it was borne in mind that the possibility of direct study of the Moon and the nearer planets could not be long delayed, while the prospects for extensive astronomical observations carried out above the atmosphere were great. The kinds of scientific problems which could profitably be attacked by rocket techniques were examined, and the limitations imposed by the requirements of orbit and aspect control, vehicle tracking, data recovery and instrument design were discussed.

Although an invitation had been given, no delegate from the Soviet Academy of Sciences was present. However, the conference was fortunate to have present Dr. H. E. Newell of the Naval Research Laboratory, Washington, who was able not only to present many American results, but also to give a broad account of the future plans of the United States. The discussion was opened by Prof. H. S. W. Massey (University College, London), who reviewed briefly the scope of impending space research, mentioned the rapid technical advances that made these discussions important, and expressed his surprise to find himself speaking of developments in planetary studies that a year or so ago would have been simply science fiction. Experimental results and theoretical considerations relevant to an understanding of the atmosphere above 100 km. were discussed by Prof. D. R. Bates (Belfast). He limited his remarks to the composition and temperature of the region and assumed a static model. The composition is determined partly by diffusive separation, which has been demonstrated both by bottle-sampling and mass-spectrometric measurements. At 150 km. the argon–nitrogen ratio has fallen to one-sixth of its ground-level value. In a static atmosphere such diffusive separation would result in the concentration of hydrogen at 400 km. being comparable with that of atomic oxygen. However, a net loss or gain of hydrogen to or from the interplanetary regions would greatly affect the concentration gradient, and there is still a need for more experimental data.

Above 100 km. oxygen is largely dissociated and above 300 km. is probably more than ten times as abundant as atomic nitrogen. Below 300 km., due to rapid recombination of atomic nitrogen by $N + O_2 \rightarrow NO + O$ and $N + NO \rightarrow N_2 + O$, nitrogen is largely molecular and has a correspondingly small scale height. The ionic constitution up to 200 km. has been found to be principally NO^+ probably formed by $O^+ + N_2 \rightarrow NO^+ + N$.

The rise of temperature above 100 km. has been found to be much greater than was commonly supposed some years ago. The fall in the concentration of electrons above the *F*-layer—measured out to 750 km. by the Russians—suggested a temperature between 1,500° K. and 2,000° K. at this height. The large temperature gradient indicates a downward heat flux of about 2 ergs/cm.^{2}/sec. and poses a considerable problem as to its origin. Prof. S. Chapman thought that the solar corona extends as far as the Earth's orbit, and, with a temperature of a quarter of a million degrees, is the source of this energy. The high maximum temperature of the corona—about a million degrees—was thought to be due to high-energy particles passing through it, though opinions differ as to whether these particles came from inside or outside the Sun. Prof. Chapman reviewed the conditions existing in the corona with special emphasis on the problem of determining its thermal conductivity in view of the existence of velocity gradients and magnetic fields. The solar magnetic field tends to rotate the corona with the Sun but probably does not penetrate very far out as it will set up an opposing ring current. The density of the corona beyond 15–20 solar radii is in doubt because of the centrifugal forces due to its rotation. However, its conductivity is, of course, independent of its density.

In spite of many efforts to obtain information on the concentration of interplanetary dust, difficulties of interpretation have prevented a consistent figure from being obtained so far. This is a pity because in sufficient, though perhaps rather unlikely, concentrations the dust might play an important part in cooling the corona. In the absence of such cooling, Prof. Chapman thought that the Earth must be regarded as a cool spot in an immensely hot gas and its atmosphere must rise in temperature from about 200° K. at 80 km. to 200,000° K. at great distances. The huge scale height implied suggests that the Earth's atmosphere may extend even as far as the Moon. The conductivity of the atmosphere due to hydrogen flowing into it might be increased five-fold because the atoms carry with them their heat of recombination.

Prof. C. F. Powell (Bristol) described the great potential value of artificial satellites to the study of fundamental problems in the physics of cosmic rays and very high-energy particles. He saw a limit to the particle energies attainable by contemporary methods at around 100 BeV. but in cosmic rays energies up to 10^9 BeV. are found. The satellite laboratory may well be the only place in which experiments on such energetic particles can be conducted for many years to come.

The abnormally high concentration of lithium, beryllium and boron in the cosmic-ray flux compared with their universal abundance is probably due to fragmentation of heavier particles during their interstellar journey. More satellite results are needed to confirm this. It seems probable, however, that a mean life of the order of 10^8 years is indicated. The long mean life and isotropic distribution suggest that the particles are stored in the fields of the galactic halo. Two possible sources of injection of these rays were contemplated, namely, supernovæ and in red and super-giant stars. Discrimination between these sources could be carried out by obtaining the mass spectrum of the rays well above the atmosphere. Thus a supernova source would result in rays rich in heavy elements, for example, thorium-254. Giants would give a spectrum similar to that of flare particles.

Satellites are particularly valuable in studying corpuscular and electromagnetic radiation from flares because of their unpredictable occurrence.

In a paper concerned with the study of the Moon and the nearer planets, Prof. T. Gold (Harvard) re-emphasized the need to study the density, motion, temperature and velocity distribution of material in the interplanetary regions. The magnetic field frozen into solar streams may entrap particles with energies ranging from 10 keV. up to 30 BeV. The importance of planetary and interplanetary magnetic fields places a high priority on a magnetometer in the allocation of the pay-load of deep-space probes.

A study of the Moon may be of value in helping us understand the geological history of our own planet. Facsimile scanning of the surface should be especially aimed to resolve the question of the origin of the lunar maria. A lunar satellite might detect a transient atmosphere on the Moon. Such an atmosphere could arise from gas emitted from the surface, or, when the Moon passed through a solar stream, as much as 3×10^5 particles/sec. might be found if the high-velocity stream were reflected with only thermal energy.

Satellite studies of the atmospheres of Mars and Venus could be carried out by spectrometric and mass spectrometric techniques. Even an Earth satellite could be of value in spectrometry of Mars, for example, since it would remove the confusion due to telluric lines. It would be interesting to look for suggestive traces of organic compounds of biological origin. The presence of water and nitrogen in the Martian atmosphere should be examined.

Prof. F. Hoyle (Cambridge) considered problems much more remote in space but in some cases quite as pressing in any plans for future space research. He reviewed the serious limitations to terrestrial astronomy occasioned by absorption, refraction, and scattering of light in the atmosphere. Astronomical observations made above the atmosphere with a 20-in. telescope would already have advantages over any made from a terrestrial observatory—quite apart from the unrestricted range in wave-length.

Use of narrow-band ultra-violet detectors, for the Lyman series, for example, would improve the signal/noise ratio for observation of distant objects because the red shift would separate the distant source from local scattering.

Studies of white dwarf stars in the ultra-violet would be especially valuable both because of their greater brightness in this region and because of the important nuclear reactions occurring in them. On the other hand, the use of infra-red detectors would make it possible to penetrate the dust clouds from which stars are formed, and would thus assist in an understanding of this basic cosmic process.

In the study of the Crab nebula and of the galaxy's gaseous envelope, where there are high-energy electrons, X-ray and γ-ray astronomy would be invaluable. Prof. Hoyle mentioned several examples of important cosmological data which we happen to possess simply because the atmospheric window is fortuitously well placed or because the limits of terrestrial vision are by chance favourable for observation. The argument that much more vital information awaits the extension of these limits seems inescapable.

Prof. A. C. B. Lovell was prevented by ill-health from attending, his place being taken by Dr. J. G. Davies of the Jodrell Bank Station, who pointed out that terrestrial radio astronomy is subject to the same basic limitations as optical astronomy. He thought that the greatest value of extra-terrestrial radio astronomy will lie in the extension of the useful spectrum beyond the ionospheric absorption limit, and in the possibility of close approaches to the Moon and planets.

Representatives of the Royal Aircraft Establishment discussed a number of practical problems in connexion with space probes and satellites. Dr. A. W. Lines stressed that stringent orbit and aspect control will be required in the near future. He set out to show how these requirements might be met in a satellite or space probe with an initial all-up weight of less than 100 tons and a first-stage thrust of about a quarter million pounds. Stabilization might be required in terrestrial, space (sidereal) or solar axes, and could conveniently be achieved by employing jet reaction initially, with motors for angular momentum storage after most of the angular momentum had been removed. Special emphasis was placed on a space stabilization system using two stars as reference points. The photoelectric equipment would be associated with gyroscopes to take control during eclipse of the stars. The precession-rate for the gyroscopes could be 'learnt' by the servo system by reference to the stellar vectors.

Mr. W. T. Blackband discussed a system for the recovery of information from vehicles as far away as the nearer planets. For a triode receiver, noise from all sources is a minimum at about 200 Mc./s., and corresponds to a source temperature around 750° K. Maser systems would give a better figure at very high frequencies. For a dish 10 m. in radius, a 10-W. transmitter and 1 c./s. band-width, Mr. Blackband obtained a signal/noise ratio of 1·2 at 10^6 km. It is evident that recovery of information is a major problem for planetary probes and recourse must be had to any or all of the following measures : considerable increase in transmitter power, even more drastic reduction of band-width, the use of masers, the use of directional aerials at the transmitter.

Position determination could be achieved by an interferometer calibrated against radio stars. A precision of 15 sec. of arc might be obtained. Stabilization of the transmitter to one part in 10^9 would enable range to be found by Doppler methods to an accuracy of 1 km. per hour of travel.

Techniques of physical measurements were reviewed by Dr. R. L. F. Boyd (University College, London). Two techniques, conspicuously absent in much work to date, are microwave spectrometry and the Langmuir probe. The former may ultimately prove a means of assaying directly the nitric oxide which plays such an important part in the ionosphere below 200 km. Some of the work at University College, London, was described. In 1959, *Skylarks* will be fired, equipped with Langmuir probes. Laboratory studies have shown that this technique may usefully be developed not only to give information on the concentration of electrons and temperature of the upper atmosphere but also to give concentration of negative ions and some degree of mass analysis. The extension of the technique to satellites and deep-space probes was discussed. Analyses of energy distributions at satellite velocities would enable discrimination to be made between oxygen and nitrogen atoms.

Considerations of Debye length, photo-emission and the return of collected current show that the technique might be applicable to a study of the solar corona and the energy distribution in solar corpuscular streams.

Prof. J. Sayers described the ionospheric work using *Skylark* rockets at the University of Birmingham. He showed a curve for electron density in a night sporadic-*E* cloud, obtained at Woomera on the Rocket World Day. It was remarkable for the thinness of the cloud—less than 3 km. Concentrations were similar to normal daytime *E* maxima. The method employed involved determination of the local refractive index from the frequency of a radio-frequency oscillator, the tank circuit of which included the insulated nose-cone of the rocket as part of its reactance. Prof. Sayers also showed a *Skylark* nose-cone instrumented with an ion spectrometer of unique design. This spectrometer is a pulsed ion chamber of 2,000 cm.^{2} aperture. It is ejected from the rocket on a long flexible cable so as to avoid contamination with rocket gases.

Probably the most dramatic and exciting discovery of the rocket and satellite programme of the International Geophysical Year has been Van Allen's work with the *Explorer* satellites, now corroborated by *Sputnik* 3. The discovery of the Van Allen belt, as it has come to be called, was made with *Explorer* 1, the Geiger counters of which were soon saturated with the intense radiation. To amplify the results from *Explorers* 1 and 3, *Explorer* 4 was instrumented with two scintillation counters (one plastic and one cæsium iodide) and two Geiger counters (one shielded). It was launched at an inclination of 51° and the results were recorded on magnetic tape, read out on command.

That the radiation belt reached a maximum intensity of more than 10,000 counts/min. at about an Earth's radius above the equator was confirmed by *Pioneer* 1. *Explorer* 1 showed evidence of a connexion between the intensity and auroral activity (and therefore solar streams). *Explorer* 4 indicated in addition the presence of a more penetrating component than the auroral electrons.

It was suggested that the radiation is largely due to solar ionized gas trapped in Störmer orbits. A rough computation of the relaxation time of the ionization gives 10^7 sec., far too long for auroræ to result directly from influx into the belt. It is suggested that the auroræ are due to leakage from the belt along the lines of magnetic force and that the increase at the advent of a solar stream is due to deflexion of the lines of force, analogous to a squeezing of the reservoir.

Mr. D. G. King-Hele of the Royal Aircraft Establishment, Farnborough, presented his results from observations of the orbits of *Sputniks* 2 and 3. The irregularities in motion can be attributed to varying air density, the westerly wind of the Earth's rotation and the second harmonic of the gravitational field. The results show that changes in air density at perigee are immediately reflected in change of time of meridian passage. The westerly wind causes a perceptible change in orbit inclination, while the rate of precession leads to an accurate estimate for the Earth's oblateness. If it is assumed that only the second harmonic of the gravitational field is significant, a new value of 1/298·16 is obtained for the elipticity compared with 1/297·6. Mr. King-Hele was of the opinion that to this degree of precision it is permissible to ignore higher harmonics. No inconsistency arises in the results obtained from satellites of various inclinations when this is done.

Two papers were presented by Dr. Newell. In the first he reviewed some of the results from inboard satellite instruments, other than cosmic-ray measurements. In the *Explorers*, micrometeors had been studied by the microphone method and environmental measurements had been made. Soon it was hoped to launch satellites to study cloud cover, the terrestrial radiation balance and magnetic field. Some micrometeor results have come from non-orbiting *Vanguards*. A flux of about $2{\cdot}5 \times 10^4$ kgm./day has been estimated but there are serious discrepancies with Soviet results.

The results on density obtained from rockets and satellites are consistent, figures of $2{\cdot}8 \times 10^{-13}$ gm. cm.$^{-3}$ at 228 km. being obtained from air drag and 1×10^{-13} and $8{\cdot}8 \times 10^{-15}$ gm. cm.$^{-3}$ at 260 km. and 355 km. respectively, from ion gauges in *Sputnik* 3.

Ionization shows a slow decline above the *F*-layer, and composition measurements using a radio-frequency ion spectrometer in *Sputnik* 3 show the oxygen ion to be the predominant ion from 250 to 950 km. The ratio of N^+/O^+ at 230 km. was found to be 3·7, rising by a factor of two at about 700 km.

In his second paper, Dr. Newell reviewed the future of American research under the National Aeronautics and Space Act. The terms of reference include: (1) expansion of human knowledge of the atmosphere and space, (2) aircraft, (3) space vehicles, (4) long-range uses of space for peace, (5) co-operation with other nations. The programme planned amounts to a review of all the basic physical studies which have become possible now that space research by rocket vehicles has become a reality.

NEWS and VIEWS

Geological Society: Awards for 1959

THE Geological Society of London has made the following awards for 1959: *Wollaston Medal* to Prof. Pierre Pruvost, professor of geology at the Sorbonne, Paris, for his researches in stratigraphy and palæontology, with special reference to his work on the Carboniferous rocks of Europe, and his stratigraphical investigations of the rocks of Brittany; *Murchison Medal* to Prof. S. E. Hollingworth, professor of geology at University College, London, for his contributions to stratigraphy, glaciology and geomorphology in north-west England and the Midlands; *Lyell Medal* to Prof. D. Williams, dean of the Royal School of Mines, for his contributions to geology, especially as applied to the discovery and exploration of mineral deposits; *Bigsby Medal* to Prof. B. C. King, professor of geology, Bedford College, London, for his contributions to the structure and petrology of Africa, especially of Nigeria, Uganda and Bechuanaland, and to the interpretation of rock transformations, ancient volcanoes and metamorphic tectonics in Scotland; *Wollaston Fund* to Dr. M. H. P. Bott, lecturer in geology in the University of Durham, for his application of geophysical methods in the elucidation of geological structures and particularly the structure of granite masses; *Murchison Fund* to Dr. D. T. Donovan, lecturer in geology in the University of Bristol, for his work on Mesozoic stratigraphy, palæogeography and palæontology, particularly in regard to the ammonites; a moiety of the *Lyell Fund* to Mr. C. O. Harvey, chemist to the Geological Survey of Great Britain during 1934–58, for services in aiding geology by chemical analyses of rocks and minerals; another moiety of the *Lyell Fund* to Dr. W. H. C. Ramsbottom, of the Geological Survey of Great Britain, for his contributions to systematic and stratigraphical palæontology, especially for his work on the Lower Palæozoic Crinoidea and on Carboniferous faunas.

U.S. National Reliability Award : Mr. R. Brewer

Mr. Ralph Brewer, of the General Electric Company Research Laboratories, Wembley, has been awarded the 1958 National Reliability Award for his paper entitled "Life Tests of Electron Tubes and the Analysis of Failure Causes", which was read at the Fourth National Symposium on Reliability and Quality Control in Electronics, held at Washington in January 1958. The award is made to the author of the best technical paper presented at this annual Symposium. Mr. Brewer's paper was the only overseas contribution in the total of fifty papers read. The symposium is jointly sponsored by the American Institute of Electrical Engineers, the Institute of Radio Engineers, the American Society for Quality Control and the Electronic Industries Association. Mr. Brewer is a member of the principal scientific staff of the General Electric Company's Research Laboratories, which he joined in 1937 to work on illumination engineering. During the War he transferred to electronic valves and worked on early radar magnetrons. After the War, he took charge of valve reliability studies, which have played an important part in the development of improved valves. His work has now extended to cover the study of the survival characteristics of transistors and related semiconductor devices as well as the general reliability problems of electronic systems.

National Institute for Research in Dairying : Prof. R. G. Baskett

Prof. Ronald Gilbert Baskett has been appointed director of the National Institute for Research in Dairying, University of Reading, as from August 1, 1959. He succeeds Prof. H. D. Kay, who has recently retired (*Nature*, 181, 1506 ; 1958). Dr. A. T. R. Mattick is at present acting director. Prof. Baskett is now professor of agricultural chemistry, the Queen's University of Belfast, and head of the Chemical and Animal Nutrition Division of the Ministry of Agriculture for Northern Ireland. He was born in 1901, and educated at King Edward VI Grammar School, Chelmsford, and University College, Reading, where he received his early training in chemistry with Prof. H. Bassett and Prof. H. A. D. Neville. His interests have centred in animal nutrition, particularly mineral metabolism. He has been especially concerned with pig husbandry and is at present a member of the Technical Committee of the Agricultural Research Council on Pig Research. Prof. Baskett has had long administrative experience in Northern Ireland coupled with teaching in the University of Belfast and examining in other universities. He also served with distinction as agricultural attaché at the British Embassy in Washington. His world-wide contacts with workers in the same field will be of great value in his new post.

Animal Husbandry at the Royal Veterinary College : Prof. J. A. Laing

The late Prof. N. J. Scorgie (see *Nature* of January 24, p. 220) has been succeeded in the Courtauld chair of animal husbandry at the Royal Veterinary College, London, by Dr. J. A. Laing, reader in veterinary science in the University of Bristol. Prof. Laing, who graduated in Edinburgh in 1941, took an early interest in problems of bovine infertility, and as an Aleen Cust Memorial Scholar worked under John Hammond at Cambridge, under whose guidance he obtained his Ph.D. in 1944. He remained in Cambridge studying particularly spermatozoa, as a research officer and then as veterinary investigation officer of the Ministry of Agriculture, until 1949, when he joined the staff of the newly formed Veterinary School of the University of Bristol. His main research interest did not waver from the general problems of animal breeding and genital infection and he attained a nation-wide and international reputation in this respect. In 1954 he was awarded a Churchill Fellowship to study in Copenhagen, and has acted as a consultant to the Food and Agriculture Organization of the United Nations, which sponsored an assignment for him to advise the Republic of Dominica on cattle infertility and allied problems during 1957–58. He was awarded the status of reader in 1957. His published works include the book "Fertility and Infertility in the Domestic Animals" (1955). Prof. Laing's breadth of experience in the field of animal reproduction will be of value in helping to develop the new field station of the Royal Veterinary College recently opened at Potters Bar.

Spert-III achieves Criticality

The special power excursion reactor test No. 3 (Spert-III), a versatile research facility developed for studying nuclear reactor safety at the U.S. Atomic Energy Commission's National Reactor Testing Station, Idaho Falls, achieved criticality on December 20. Spert-III is one of a series of reactors designed and developed by Phillips Petroleum Co. as part of the Atomic Energy Commission's programme to find basic explanations for the behaviour of reactors under runaway conditions. All operations are conducted by remote control, since some of the tests approach destruction of the reactor. This facility provides the widest practical range of control over three variables—temperature, pressure, and rate of flow of coolant. The plant is expected to contribute significantly to a better understanding of reactor self-limiting and occasional instability characteristics exhibited in an earlier experimental reactor, Spert-I.

Spert-I, which began operation in July 1955, was the first of a series established to investigate potential hazards associated with the broad class of heterogeneous, water-moderated, enriched-fuel reactors. Spert-II, which is still under construction, is intended to continue similar studies with special emphasis on how various moderators and reflectors, including heavy water, influence reactor behaviour. Tests in Spert-I, using a simple open-tank system, are generally characterized by sudden power rises (one reaching $2 \cdot 8 \times 10^9$ watts) that are arrested by the inherent self-limiting tendency of the reactor itself. Without any manipulation of the control rods, reactor power reaches a peak in a fraction of a second and drops off to much lower but generally steady levels. In some cases, however, instabilities also are observed following the power peaks. Some of these are divergent oscillations that could probably destroy the reactor, despite its self-limiting characteristics, if allowed to continue. The precise causes of self-limitation and of these power instabilities are not known, but form the principal objective of the present project.

Atomic Energy Information

In order to make atomic information more easily available, the U.K. Atomic Energy Authority has decided to make fuller use of microphotography. The effect of this will be to make all non-secret reports which have been prepared since 1947 readily obtainable. Complete sets are also being presented to a number of other countries and to certain international agencies. In addition to this, the Authority is increasing its facilities for supplying reports in conventional form as they are prepared. From February 16 a large number of unclassified and declassified reports, which have hitherto been obtainable only on loan from Atomic Energy Authority libraries, will be available in micro form. Arrangements have been made with Micro Methods, Ltd., of East Ardsley, Wakefield, Yorks, for the production of microcopies on card of all unclassified and declassified reports issued between 1947 and December 1956 and, on a continuing basis, of those reports issued since 1956 which are not available on sale from H.M. Stationery Office. Microcopies may be purchased from Micro Methods.

Sands of Forvie Nature Reserve

SANDS of Forvie, Aberdeenshire (1,774 acres), which has been declared a new Nature Reserve by the Nature Conservancy, under an agreement with the Walker Scottish Estates Co., Ltd., the owners, lies on the coast near Newburgh, between the mouth of the River Ythan and the village of Collieston. It consists of a broad foreshore backed by a line of dunes, behind which are slacks and more stable dunes passing inland to dune heath and rough pastures. To the north of the low sandy shore and the seaward dunes there are cliffs of schists and gneisses overlain by boulder clay. This rocky part of the coast includes Hackley Head and Hackley Bay. Inland from Collieston are two small freshwater lochs—Sand Loch and Cotehill Loch.

The chief botanical interest lies in the plant communities of the dunes. Marram grass (*Ammophila arenaria*) is the dominant species on the shifting dunes, while the sand sedge (*Carex arenaria*), the jointed rush (*Juncus articulatus*) and silver weed (*Potentilla anserina*) are generally among the earliest established dominants on the sheltered, moist dune plains. Mat grass (*Nardus stricta*), crowberry (*Empetrum nigrum*), creeping willow (*Salix repens*), cross-leaved heath (*Erica tetralix*) and ling (*Calluna vulgaris*) become prominent in later stages of the succession inland to the fixed dunes. The crowberry plants, conspicuous over large areas, are usually associated with lichens, forming a distinctive *Empetrum*-lichen heath community. The lesser spearwort (*Ranunculus flammula*) and the toad rush (*Juncus bufonius*) are characteristic of the wetter dune hollows which are often locally rich in mosses. Birds breeding within the area include eider (a particularly large nesting population), shoveller, shelduck, red grouse, little tern, arctic tern, common tern, sandwich tern, and fulmar. The whole area offers excellent opportunities for developing physiographical and biological observation and research. Among the dunes there are important Late Bronze and Early Iron Age sites which have yielded stone implements and pottery, and comprising stone circles, a flat ring cairn and kitchen middens.

Microbiological Defence Research

IN reply to a question in the House of Commons on January 26 regarding the Microbiological Research Centre and the Chemical Defence Experimental Establishment, the Minister of Supply, Mr. A. Jones, said that the Ministry of Supply Establishments at Porton are mainly engaged in research on defensive problems of microbiological and chemical warfare. The investigations are essentially directed towards assessing the threat and providing defences against it, and most of the results obtained are published in the scientific literature. The danger from botulinus toxin is included, but this danger has been grossly exaggerated, since the toxin cannot be easily disseminated and is not self-propagating. Useful defensive measures against it are known.

Scientific Research in South African Universities

THE Register of Current Scientific Research at South African Universities, 1957 (pp. viii+198. Pretoria: South African Council for Scientific and Industrial Research, 1958), is the fifth of the series of annual volumes listing research projects in the natural sciences being undertaken at South African universities and intended to meet the needs of research workers in South Africa and elsewhere. The information is given in the language in which it was received from the universities, but an English translation of Afrikaans entries is provided, and the alphabetical order of the subject-matter is determined by the English heading. As in previous volumes, entries are grouped under subjects, corresponding roughly with departmental divisions in the universities, and under these headings are arranged all the research projects in that subject in each university in turn. There are also an author and a subject index.

The Nucleus

IN view of the spectacular advance made in recent years in the field of genetics, there is a growing need for more information about the physical basis of genetic phenomena. *The Nucleus*, an international journal of cytology and allied topics, recently published, has this aim (*The Nucleus*, 1, No. 1; June 1958. Pp. 152. Calcutta: Dr. A. K. Sharma, Editor, Botany Department, The University, 1958; annual subscription 10.50 dollars or Rs. 46.00). The contributions in the first issue deal with descriptive cytology, chromosome dynamics, chemical and radiation effects on chromosomes and the mitotic process, and include a scholarly study on the possible role of nuclear membrane detachment in cytoplasmic organization. The international advisory board consists of H. Kihara (Japan), H. P. Riley, B. P. Kaufmann and J. H. Taylor (United States), F. Oehlkers (Germany), A. Löve (Canada) and M. J. Sirk (Holland). The editor is Dr. A. K. Sharma. The style of printing and the photographic reproductions can compare favourably with any other well-established publication.

Fourth Congress on Theoretical and Applied Mechanics

THE fourth Congress on Theoretical and Applied Mechanics was held at the Bengal Engineering College, Howrah, during December 28–31, under the presidency of Dr. S. R. Sen Gupta, director of the Indian Institute of Technology, Kharagpur. About two hundred and fifty scientists and engineers, including members from Australia, Burma, Czechoslovakia, Egypt, Hungary, Italy, Japan, Poland, the United States and the U.S.S.R. attended. Some forty original papers were read, on subjects including finite deformation, visco-elasticity, stress waves, stresses in strips, columns and disks, plasticity, elasto-porosity, vibration and stability, fluid-flow, ballistics and statistics.

Dr. A. N. Khosla was elected president for the next two years; Dr. S. K. Chakravarty was elected vice-president in the vacancy created by the retirement of Sri V. Cadambe; Prof. B. R. Seth was re-elected secretary-treasurer for the next three years; and Dr. Jai Kishan, Prof. B. Sen Gupta and Prof. D. Banerjee were elected new members of the Executive Committee. The Executive Committee accepted the invitation of the University of Roorkee to hold the fifth Congress in Roorkee in December 1959.

The Emissivity of the Earth's Surface

Loss of heat by radiation from the Earth's surface is one of the fundamental physical factors of meteorology. J. T. Houghton (*Quart. J. Roy. Meteor. Soc.*, 84, 448; 1958) describes measurements with airborne radiometers at night which permit a comparison to be made between the temperature of the Earth's surface and the black-body temperature of the radiating surface computed from the upward flux of radiation at 200 ft. and the temperature and humidity of the intervening atmosphere. At this height about 60 per cent of the upward radiation comes directly from the surface. The observations gave a black-body temperature between the screen temperature and the ground temperature. Thus on one occasion over north-east Hampshire the effective black-body temperature was 3·2° C., whereas the screen temperature was 4·7° C. and the ground temperature 2·7° C. It appears that heath and arable lands radiate as black-bodies with an emissivity of 100 per cent. One observation over the English Channel, however, gave an effective temperature about 2 deg. C. higher than the screen and sea temperatures observed nearby at the *Royal Sovereign* lightship. An observation made just above a layer of stratus cloud at 3,000 ft. gave an emissivity of 100 per cent for the cloud.

A Mongolian Earthquake

A VIOLENT earthquake occurred on December 4, 1957, in the region of the Gurvan Bogdo mountain chain belonging to the Gobi–Altai system. In January 1958 a joint Mongolian–Russian scientific expedition proceeded to this region, and a brief account of the findings is presented by N. A. Florensov (*Priroda*, 7, 73; 1958). The region affected by the earthquake is a belt some 270 km. in length containing a system of branching fault fractures, many of them marked by very long fault scarps. The earthquake greatly affected overground and underground waters and the relief of the country.

Powder Patterns of Ferroelectric Domains

FOR more than fifty years red lead and sulphur have been used for picking out differently charged portions of the surfaces of insulators. Recently, however, G. L. Pearson and W. L. Feldmann, of the Bell Telephone Laboratories. New York, have used these substances in suspension in hexane to pick out positively and negatively charged domains, respectively, on the surfaces of ferroelectrics. The suspensions are applied separately; one after the other has dried on the surface under investigation. The lead oxide may be replaced by a dispersion of a cross-linked polymer derived from polystyrene. It is also found that colloidal particles of barium titanate, which have a very high dielectric constant, are deposited at ferroelectric domain boundaries, and this technique has given new information concerning domain structures of a number of ferroelectrics.

Four Rare Indian Animals

UNTIL 1952 there was no agency in India directly concerned with the preservation of the country's wild life, and the Forest Departments of the various States were able to give only a limited measure of protection within certain of the reserved forests under their jurisdiction. In that year the setting up of the Indian Board for Wild Life to advise the Central Government in New Delhi was an important event in Nature conservation in India. It was followed within a short time by the constitution of State Wild Life Boards in nearly all the States of the Indian Union. Now several States also possess separate Wild Life Departments, within the Forest Department, concerned solely with the preservation of wild life. The creation of these Boards at Central and State levels has not been followed by any remarkable results, nor has there been any marked improvement in the general position of wild life over the whole country. But the publicity given in the Press and elsewhere has succeeded in focusing public attention on the need to protect the country's rare and vanishing species and on the desirability of maintaining and developing wild-life reserves. As a result, writes E. P. Gee (*Oryx*, 4, No. 2; 1958), the status to-day of the Indian rhinoceros, Indian lion, brow-antlered deer and Kashmir stag is more secure than it has been since the lowest recorded levels of these species.

Gordon Childe Memorial Fund

THE issue of *Man* of October, 1958, contains an appeal for a Gordon Childe Memorial Fund. Details have not yet been worked out and everything will depend, of course, on the amount of money available. Any friend or admirer of the late Prof. Gordon Childe can send a subscription, now, to the Secretary, University of London Institute of Archæology, 31–34 Gordon Square, London, W.C.1.

Ramsay Memorial Fellowships for Advanced Students of Chemistry

THE Trustees will consider in June applications for two Ramsay Memorial Fellowships for advanced students of chemistry. One of the Fellowships will be limited to candidates educated in Glasgow, who can apply to be considered for either Fellowship. The value of each Fellowship will be £600 per annum, to which may be added a grant for expenses of research not exceeding £100 per annum. The Fellowships will normally be tenable for two years. Full particulars can be obtained from the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1. Completed application forms must be received not later than April 13.

Mond Nickel Fellowships

MOND NICKEL FELLOWSHIPS are intended to enable selected British graduates to obtain additional training and wider experience in industrial establishments, in Britain or abroad, so that, if they are afterwards employed in executive or administrative positions in the British metallurgical industries, they will be better qualified to appreciate the technological significance of research and to apply its results. It is also hoped that the training facilities provided will attract persons qualified in sciences other than metallurgy into the metallurgical field. Each Fellowship will occupy one full working year;

it is hoped to award five Fellowships each year of an approximate value of £900–£1,200 each. Further particulars and forms of application can be obtained from the Secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, London, S.W.1. Completed forms must be returned not later than June 1, 1959.

The Creole Foundation Prize

THE Creole Foundation, created by the Creole Petroleum Corporation—which is affiliated to the Standard Oil Company of New Jersey, and operates in Venezuela—with the object of encouraging the development of university, technical and industrial education and of scientific research in general, is offering a prize to be known as the Creole Foundation Prize. This will consist of 10,000 U.S. dollars and a diploma to be awarded to the author or authors of a work, selected through a competition, on any aspect of Venezuela in the fields of the natural, physical or social sciences. The prize will be given every two years in Caracas, beginning on October 17, 1960, the anniversary date of the creation of the Foundation; travelling and living expenses to Caracas will also be paid. Works to be submitted for the competition, which may be of any length and must either be written in Spanish, English, French, German, Italian or Portuguese or be accompanied by an adequate summary in one of those languages, must be received before December 31 in the year immediately preceding that in which the prize is to be awarded, at Premio Fundacion Creole, Apartado 889, Caracas, Venezuela, from which further information can be obtained.

University News: London

THE title of professor of physiology in the University of London has been conferred on Dr. J. A. B. Gray in respect of his post at University College. The title of reader in physics in the University has been conferred on Dr. R. L. F. Boyd in respect of his post at University College; and that of reader in political economy in the University has been conferred on Mr. W. J. Corlett in respect of his post at University College. Dr. M. J. Seaton, lecturer at University College, has been appointed to the University readership in physics tenable at that College.

Announcements

SIR GEORGE R. EDWARDS, managing director of Vickers-Armstrongs (Aircraft), Ltd., and immediate past president of the Royal Aeronautical Society, has been made an Honorary Fellow of the American Institute of the Aeronautical Sciences. Dr. A. M. Ballantyne, secretary of the Royal Aeronautical Society, has been elected a Fellow of the Institute of the Aeronautical Sciences.

THE Swiney Prize of the Royal Society of Arts for the best published work on medical jurisprudence has been awarded to Dr. Keith Simpson, reader in forensic medicine to the University of London at Guy's Hospital Medical School, for his book, "Forensic Medicine" (third edition). The Prize, which consists of £100 and a silver cup of the same value, is awarded on every fifth anniversary of Dr. George Swiney's death in 1844 for the best published work alternately on medical and general jurisprudence. The award is made by a joint committee of the Royal Society of Arts and the Royal College of Physicians.

ON his resignation from the post of assistant secretary of the Royal Meteorological Society, Mr. M. E. Shoenberg has been made a life-member of the Society. His successor at the Society is Mr. R. H. Levinson.

PROF. A. N. DUCKHAM has been appointed chairman of the Milk and Milk Products Technical Advisory Committee of the Ministry of Agriculture, Fisheries and Food in succession to Prof. H. D. Kay.

GRIFFIN AND GEORGE (RESEARCH AND DEVELOPMENT), LTD., has been formed by the Griffin and George Group to conduct research into, and the development of, new and improved scientific instruments and apparatus for laboratory use and process control. Dr. A. J. P. Martin, well known for his work on partition chromatography, acknowledged by the award in 1952 of the Nobel Prize for chemistry (jointly with Dr. R. Synge), has been appointed research director.

THE Ergonomics Research Society is holding a symposium on "Ergonomics: its Place in Industry" in Oxford during April 6–9. The symposium is intended to provide an opportunity for reviewing progress in the field of ergonomics research and application and for considering future developments in this field. Further information can be obtained from Dr. S. Griew, Department of Psychology, 22 Berkeley Square, Bristol 2.

THE Institute of Physics is arranging a one-day symposium entitled "Current Developments in the Production of High Vacua", to be held in London on April 17. There will be three sessions devoted to chemical and ionic pumping in kinetic vacuum systems; problems in the production of high vacua in large equipment; and analysis of residual gases in kinetic vacuum systems. Abstracts (but not preprints) will be circulated before the symposium, the proceedings of which will not be published in full. All inquiries should be addressed to the Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1.

THE University of Liverpool is arranging a special Conference on Mathematics, to be held at Derby Hall, Liverpool, during April 5–11. The Conference is intended to provide an opportunity for teachers of mathematics in grammar schools, technical colleges and universities to meet mathematicians employed in industry, government establishments and research organizations, and learn something at first hand of mathematics in action. Prof. Louis Rosenhead will be chairman of the Conference, which will be mainly residential, but arrangements are being made to enable local teachers to attend on a non-residential basis. Inquiries should be addressed to the Director of Extra-Mural Studies, The University, Liverpool.

THE Proceedings of the International Congress on Radiation Research, held in Burlington, Vermont, during August 11–15, will soon be published by the Academic Press, Inc. The volume will be Supplement 1 of the journal *Radiation Research*, and has been edited by Douglas E. Smith, Argonne National Laboratory, Lemont, Illinois.

ERRATUM. In the communication entitled "Population Differentiation within Plant Species in Response to Soil Factors" in *Nature* of January 10, p. 129, the names against the curves in Fig. 1 should be interchanged.

PLANT PHYSIOLOGY IN CZECHOSLOVAKIA

By Prof. WALTER STILES, F.R.S.

AT the invitation, and as the guest, of the Czechoslovak Academy of Sciences, I recently had the opportunity of visiting a number of plant physiological research establishments in Czechoslovakia. Since, so far as I know, few if any British plant physiologists have visited these institutions during the past twenty years, a brief impression of them may be of interest to Western readers.

In Prague, plant physiological research is carried out in two institutions, the Charles University and the Biological Institute of the Academy of Sciences. As most readers will know, the Charles University is one of the oldest in Europe, having been founded in the year 1348. For a time, in the latter part of the nineteenth and first part of the twentieth centuries, there were two universities in Prague, a Czech and a German, but since the War no such division of university administration any longer exists. The plant physiological department of the University, under the direction of Prof. S. Prát, is housed in the buildings of what was formerly the German University, which will be associated in the minds of older botanists with such well-known names as Molisch and Czapek. It is perhaps less well known that Sachs, who with reason has been regarded as the founder of modern plant physiology, worked for a time in Prague. These buildings are now sixty years old, but are spacious and well equipped, and the fine library with its large collection of pamphlets happily survived the German occupation although, unfortunately, the index of these was destroyed. Here much research is in progress under Prof. Prát's direction, as is indicated by the considerable body of publications which have appeared from his department during the past twelve years. Of work being carried out at present, particular attention is being given to the absorption of humic substances and their influence on plant metabolic processes. As botanists in Britain will know, a large collection of pure cultures of algae was made in Prague by Prof. E. G. Pringsheim and a collection of them was instituted in Cambridge during his residence there. Although many of his original cultures were lost to Prague after his departure from that city, others have been added and there is now maintained in the plant physiological department of the Charles University a large collection of cultures, not only of algae, including Cyanophyceae, but also of liverworts and mosses.

In the chair at the Charles University, Prof. Prát succeeded Prof. B. Němec, whose plant physiological researches in many fields won him a world-wide reputation half a century ago. It was a particular pleasure to me again to meet Prof. Němec and to be able to report to the many admirers of his work that in his eighty-sixth year he is hale and hearty and alert. To commemorate his eighty-fifth birthday in March 1958 a memorial volume entitled "Studies in Plant Physiology" was produced by the Czechoslovak Academy of Sciences and in which twenty-four distinguished botanists from many countries, including the United States, France, Holland, West Germany and Yugoslavia, as well as Central and Eastern European countries, contributed. It is interesting to note that among those paying tribute to Prof. Němec in this way was another veteran plant physiologist, Prof. W. J. V. Osterhout.

The Institute of Biology of the Czechoslovak Academy of Sciences has been so called since 1952, when the Academy was constituted; actually the building dates from 1926, having originally been devoted to research in agronomy and phytopathology. During 1950–52 it housed the Central Institute of Biology and Central Institute of Chemistry. The Institute is under the direct auspices of the Academy and is a purely research institution under the direction of Dr. I. Málek. Not only plant physiology but other experimental aspects of biology are dealt with here; these include microbiology, phytopathology, parasitology, radiobiology and electron microscopy among others. About a hundred research workers are engaged in investigations in the Institute. Among research projects of interest to plant physiologists are investigations on the relations between osmotic value and water deficit, cytochemical researches on mitochondria and their relation to plastids, and bud development in relation to the season of maturity and biennial bearing. Although the present buildings impress one as modern and very well equipped, new buildings for the purpose of biological research are being built.

In Brno, plant physiological work is in progress in two institutions, the laboratory for plant physiology and anatomy of the University and the Botanical Institute of the Technical University. In the former, under the direction of Prof. V. Rypáček, several researches of interest to plant physiologists are in progress. Among these may be mentioned the investigation of the growth and action of a number of wood-destroying fungi, including their effect on the composition of the attacked wood, the action of humic acid on the growth of plants, and the effect of one plant on another, with particular reference to the influence of couch grass on wheat, an effect which appears to be very striking. In the Technical University, Prof. R. Dostál, whose first work on correlation was published fifty years ago, many years before the word auxin had even been thought of, is still working enthusiastically on problems of correlation. Here, in the city where Mendel lived and worked, I was pleased to visit the little monastery garden where he carried out his pioneer experiments. In the garden is a stone with an inscription in Czech, German and French recording the fact that here Mendel carried out his experiments.

In Bratislava, the capital of Slovakia, scientific interests are in the care of the Slovak Academy of Sciences, while at the Comenius University plant physiology is in the charge of Prof. L. Pastýrik. The plant physiological laboratory here dates from 1936, and it is interesting to note that it was at first under the direction of Prof. B. Němec. Here a main plant physiological interest is in the mineral nutrition of plants. Thus, work has recently been published on the movement and accumulation of mineral nutrients in the xylem and phloem of apple and pear trees and on the dependence of the metabolism of tobacco leaves on micro-nutrients.

The site has been cleared in Bratislava for a new institute which will house plant physiology. If this is equal in quality to the fine Institute of Biochemistry maintained by the Slovak Academy of Sciences, plant physiology will be well provided for in the capital of Slovakia.

The time at my disposal did not permit me to visit Košice in the south-east of Slovakia ; but I was given to understand that work of high quality on photosynthesis was in progress there.

Archæology, although outside my range of special knowledge, is within my field of general interests, and I was therefore pleased to visit the Archæological Institute of the Slovak Academy of Sciences at Nitra. This is appropriately housed in Nitra Castle and is provided with a fine library and laboratories well equipped on modern lines.

I cannot conclude this brief account of my impressions of plant physiological activities in Czechoslovakia without expressing my indebtedness to the Czechoslovak Academy of Sciences and the Slovak Academy of Sciences for the excellent arrangements made for my visits to the various research institutions and of my deep appreciation of the friendliness and kindness I experienced from everyone I met in Czechoslovakia and particularly from my plant physiological colleagues in Prague, Brno and Bratislava and from the director and staff of the Archæological Institute in Nitra.

SELF-REGULATION IN LIVING SYSTEMS

SYMPOSIUM AT OTTAWA

A SHORT symposium on self-regulation in living systems, organized by Dr. D. K. C. MacDonald, was held at the laboratories of the National Research Council in Ottawa on October 20. About twenty-five representatives of a wide range of professions—biophysics, electrical engineering, mathematics, neurology, philosophy, physics, psychology and zoology—took part in the symposium and an attempt was made to establish some common ground within these fields through problems of interest to all. This first meeting was necessarily of an exploratory nature.

The problem of self-regulation in living systems may be considered on two levels. First, the details of self-regulation within a given animal (homeostasis) and its perception of and reaction to the external world, both of these tasks being handled by the nervous system. This might be termed the microscopic picture. Second, there is the relation of animal populations with their surroundings (ecology)—or the macroscopic level. In both cases the processes involved are analogous to those found in the inanimate control systems of physics and engineering.

Papers outlining our knowledge of the nervous system were read by Dr. B. Delisle Burns and Dr. P. M. Milner, both of McGill University, and by Dr. E. A. Atack (Ottawa). A nerve cell, or neurone, when stimulated sufficiently, will transmit the signal to other neurones which are connected to it. This period of activity is followed by a refractory period, or 'dead-time', and thus the mode of action is analogous to a Geiger counter tube. In the control centres of an animal the neurones appear to be connected together in an unorganized fashion (a useful genetic property) to form a 'nerve net'. A mathematical treatment of the propagation of signals within such nets has been given by Beurle (1956). Nerve nets in the lower control centres are responsible for self-sustaining processes within the body. For example, the control of respiration is due to nets located within the brain stem. The processes of learning and memory appear to be associated with the nerve nets located in the cerebral cortex or outer layer of the brain. It is supposed that repeated applications of the same stimulus produce some change in the neurones affected by it (or in their connexions), and thus pathways within the nets become established. Similarly, an association of pathways may be built up. Thus memory seems to be due to combinations of neurones. Since, in man, there are about 10^{10} neurones involved the total possibilities are obviously enormous—in marked contrast to insects (where the relevant number is of the order 10^3) which nevertheless show an apparently complex behaviour. Cerebral malfunctioning may affect the internal workings of the body or show external effects. Thus analysis of pathological symptoms will suggest the site of a particular disturbance.

A particular aspect of the nervous system, the handling of visual information, can be readily demonstrated. Dr. A. Burton (University of Western Ontario) presented some rather sophisticated optical illusions exhibiting : (1) a biochemical cycle in the retina, (2) adaptation in the cerebral cortex, and (3) the subjective nature of much visual information.

There was, inevitably, a discussion on the relation of computing machines to the brain, initiated by Dr. D. K. C. MacDonald (National Research Council). The ability of present-day computors to make decisions involving some long-term strategy was emphasized. It was suggested in the discussion that a distinction between an animal and a machine could be made in terms of the responses of an animal at 'higher' levels (for example, pleasure, pain) and by the fact that an animal does not always appear to behave logically.

Some large-scale aspects of self-regulation were summarized by Dr. Max Dunbar (McGill University). Particular ecological systems were discussed and it was concluded that a non-oscillatory state provides optimum conditions for survival. (Indeed, violent oscillations may prove lethal to a particular species.) Some animals contribute to stable conditions by relatively inefficient breeding habits and by tendencies or conditions leading to a high death-rate. Relations between population-levels of various species are often analogous to feedback system characteristics. It seems, therefore, that ecological systems may show an apparent ability to 'learn'. Of interest here is J. Z. Young's description of the brain as an ecology of nerve cells.

The freely ranging discussion provoked by all the papers indicated that the gaps between the various disciplines had certainly been narrowed. It is hoped that a further symposium on a similar topic will be organized in the near future. An informal report of this symposium is in preparation. DOUGLAS L. MARTIN

THE INDIAN AGRICULTURAL RESEARCH INSTITUTE

THE Indian Agricultural Research Institute has been accorded the status of a university with power to confer the degrees of M.Sc. and Ph.D. in all the important aspects of agricultural science. The new Postgraduate School was formally inaugurated on October 6, 1958, by Shri Ajit Prasad Jain, Minister for Food and Agriculture in the Government of India.

The Institute is popularly known as the Pusa Institute, after a small village called Pusa in Bihar, where it was first established as the Imperial Agricultural Institute in 1905 with a gift of £30,000 from Mr. Henry Phipps, an American philanthropist. It has now developed into a centre of considerable size, providing facilities for training and research in almost all the important branches of agricultural science. These various activities are carried out by its seven Divisions, covering, respectively, agronomy, botany, mycology and plant pathology, entomology, horticulture, soil science and agricultural chemistry, and agricultural engineering, under the over-all supervision of the director, Dr. B. P. Pal. All the Divisions are housed separately in spacious buildings, furnished with modern equipment, and each is staffed with teachers and specialists in the appropriate field.

The Institute has inherited a great tradition of agricultural research and education, going back to the work of Leather in agricultural chemistry, of Butler on fungi and fungal diseases of plants, of Maxwell-Lefroy and Fletcher in cataloguing and combating insect pests, of the Howards in breeding the early 'Pusa' wheats, and of Venkataraman in breeding Coimbatore canes. High among the recent achievements are the breeding of *NP* ('New Pusa') wheats, of which *NP* 710 and *NP* 718 combine considerable resistance to rust with high resistance to loose smut. An outstanding success is the breeding of *NP* 809 wheat for the hills, uniting resistance to the three rusts. Among other contributions of note are the building up of a fine milch herd of the Sahiwal breed; the construction of schedules for the control of some important diseases of sugar cane; and the improvement of techniques of breeding parasites for the biological control of some insect pests of crop plants.

The Library, which receives more than a thousand periodicals and possesses almost all the important publications on agricultural science, is considered to be the best agricultural library in the East, and caters for the needs of agricultural scientists all over India. Other assets of the Institute include collections of varieties of crop plants from which the plant breeder can select the genes for his breeding work; the National Collection of Insects; the Herbarium Cryptogramme Indiae Orientalis, one of the best assemblages of fungi in the East; and the Indian Type Culture Collection.

The archives of the Institute show that, from its inception in 1905, it was meant to be a central organization of postgraduate teaching. In 1923, two-year postgraduate courses leading to the award of the diploma of the associateship of the Imperial Agricultural Research Institute were instituted, offering limited facilities to students in specialized fields, without, however, offering any definite courses. In 1945 the system of training was thoroughly reorganized, courses and syllabuses were prescribed and a system of examinations introduced. The diploma awarded is comparable with the M.Sc. degree of a university.

The present decision to provide the Institute with a Postgraduate School is a natural step in fulfilling the objects which the planners of the Institute had in view. The recommendations of the Indo-American team on agricultural research and education were instrumental in giving shape to the ideals of its founders. The Postgraduate School, which will mainly be responsible for carrying out the teaching programme, has come into existence with the generous aid of the Rockefeller Foundation. The aim is to train leaders for the programme to improve agricultural technology in India.

The students will have a large number of courses to choose from, including crop husbandry, soil and water management, agricultural extension; plant breeding and genetics, cytogenetics and plant physiology; taxonomy, ecology, toxicology, parasitology, and physiology of insects; pomology, olericulture, fruit and vegetable preservation; mycology and plant pathology; soil science and agricultural chemistry; and agricultural engineering. Courses in experimental statistics will be offered in co-operation with the Indian Council of Agricultural Research.

Provision has been made, for the present, for admitting each year up to one hundred students for the M.Sc. degree and fifty students for the Ph.D. degree.

B. P. PAL

THE EMPLOYEE'S POINT OF VIEW

IN the middle nineteen-thirties, the National Institute of Industrial Psychology was asked by a large and well-known company to help in solving a staffing problem. The company's employment policy was progressive, and reasons for a very high rate of leaving were obscure. It was arranged to take the (then) unorthodox step of inviting employees to come, in confidence, to the Institute's investigator to give suggestions for improvements in their working conditions or to mention features of them which they would like to see changed. These interviews had far-reaching results; from their success stems a technique which has been fruitfully applied in the United Kingdom to the diagnosis of many working situations, in industry, shops and offices, hospitals and voluntary organizations. It brings to the study of people in their working environment, and particularly in relation to difficulties they experience, a special combination of human understanding with scientific discipline.

The core of the method consists in confidential, undirected interviews with a sample of employees of all levels; the interviews are conducted by an impartial investigator who is not on the staff of the organization, and in whose freedom from bias all concerned may have confidence.

After many years of experience, during which the Institute's technique in this work was progressively improved, there was developed a standard system for classifying subjects raised in such interviews. It provided convenient, ordered categories to which could be assigned remarks relating to any aspect of working life, and it was intended to facilitate future study of the accumulating material.

Dr. Isabel Blain has now made a pilot study of results collected and reported by these methods within a recent two-year period (Comments on the Job. Nat. Inst. Indust. Psych., Rep. 13, 1958). The data came from six firms ; all were manufacturing companies, and apparently had little in common save their concern over some aspect of their organization or operation, to improve which they had invited the Institute's help. They differed in size of pay-roll, form of ownership, geographical position, age, history and tradition, arrangements of hours and shifts, degree of trades union influence, amenities, welfare provisions, and physical working conditions. The purpose of the study was to see whether, in spite of these differences, similarities would be found in the spontaneous remarks made by 1,678 factory staff and operatives.

Some of the salient points which emerged showed a surprising degree of similarity in each of the firms investigated. Thus, planning and control procedures, timing, time standards and time allowances, maintenance and stores arrangements were common topics of complaint.

Practice and policy relating to training, promotion and transfer were criticized, sometimes through ignorance, sometimes justifiably, due to acknowledged defects ; but there were also instances where approval was expressed of company action in these fields.

On matters of pay, men complained more frequently than women about the amounts earned ; but the greatest body of critical comment related to financial incentive schemes and to differentials.

In every company there were remarks about the inadequate definition of responsibility and authority ; similarly, poor liaison between shifts or between departments was commonly mentioned ; there were also frequent complaints about lack of information from management.

PATTERN OF SYNTHESIS OF DEOXYRIBONUCLEIC ACID IN *BACILLUS CEREUS* GROWING SYNCHRONOUSLY OUT OF SPORES

By DR. I. ELIZABETH YOUNG and PROF. PHILIP C. FITZ-JAMES

Department of Bacteriology and Immunology and Department of Biochemistry, University of Western Ontario

VARYING degrees of synchrony of bacterial cell division have been achieved by prior subjection of the cell population to chilling[1], cycles of chilling and warming[2–5], to starvation followed by replenishment[6,7] and by separation of the cells into a homogeneous group by fractional filtration[8]. In all such cases synchrony "is initiated by a phase of recovery from imposed stress and unbalance"[6] and in some there is evidence that interference with the synthesis of deoxyribonucleic acid is the critical feature[9]. It has already been shown that the initial duplication of the chromatin body of synchronously germinated spores (*B. megaterium* and *B. cereus*) is accompanied by a linear synthesis of deoxyribonucleic acid[10]. But, as no cellular division occurred prior to these doublings, no data were available regarding the relationship between synthesis of deoxyribonucleic acid and the normal division cycle. Such has now been obtained from a combined cytological and chemical study of *B. cereus* in which synchronous germination of spores was followed by two successive periods of synchronous cell division.

Uniform batches of spores were harvested from either the agar medium of Howie and Cruickshank[11] or a fluid medium (glutamine–casein–yeast) developed for the study of synchronous spore formation[12]. Spores were washed free of all traces of cell debris by eight cycles of differential centrifugation from water. Spore counts were made on appropriate dilutions of the final clean suspension.

The germination medium used was similar to that already described[10]. Spores sufficient to give a final concentration of $0{\cdot}6 \times 10^9$/ml. were inoculated below the surface of the medium, which had been warmed to 37° C. Aeration by shaking was begun immediately, and after 3 min. a drop of tri-*n*-butyl citrate was added to counteract foaming.

Cells centrifuged from rapidly chilled samples were washed in quick succession with ice-cold bicarbonate buffer, 50 per cent ethanol in buffer and absolute ethanol. Following disruption of the cells with glass beads (Ballotini No. 12) in the Mickle[13] tissue disintegrator, deoxyribonucleic acid was extracted by the Schmidt and Thannhauser procedure[14] and estimated by the Dische reaction[15]. At each time period of analysis, the living cells were examined in the phase-contrast microscope and osmium-fixed impression smears stained by an azure *A*–Feulgen procedure[16] were examined under the light microscope.

In order to obtain good synchrony through the first two divisions of the emergent cells, it was considered necessary that 95 per cent of the spores lose refractility and stain deeply with crystal violet (that is, begin germination) during a 1-min. interval commencing 1½–2 min. following inoculation. Occasionally this degree of synchrony could be obtained with fresh spores. In such cases prior activation with sublethal heating[17] (70° C. for 15 min.) did not improve the degree of synchrony. However, heat treatment usually decreased the response time of germination and made synchrony more readily attainable. It should be stressed that the subsequent pattern of synthesis of deoxyribonucleic acid was the same whether or not the spores were activated by heat.

In Fig. 1, the content of deoxyribonucleic acid of a culture is plotted as a function of the initial number of spores from resting spores (zero time) to the end of the second division of the emergent cells. The rise associated with the initial duplication of the spore chromatin body (Fig. 1, up to 60 min.) has been described earlier[10]. In three separate experiments, no alteration in the rate of synthesis of deoxyribonucleic acid followed this initial doubling of the acid and duplication of the nuclear body. It could be seen from the nuclear-stained preparations and from the phase-contrast appearance of the living cells that the first cell division began about 72 min. after inoculation (Fig. 2) and was complete some 6–8 min. later. Direct cell counts at these times confirmed these observations.

At the beginning of division, each cell contained $2\frac{3}{4}$ times the average amount of deoxyribonucleic acid found in the original spore. At the end of division this had risen to 3 times, so that each new cell now contained $1\frac{1}{2}$ times the spore amount of deoxyribonucleic acid. After division, synthesis again continued in a linear fashion but at a slightly greater rate than before, until each new cell once more entered division with $2\frac{3}{4}$ times the spore-level of deoxyribonucleic acid (Figs. 1 and 2). Duplication and separation of the nuclear bodies thus occur midway between cell divisions and during a period of continuing synthesis of deoxyribonucleic acid (Fig. 2).

Since the deoxyribonucleic acid content of a *Bacillus* cell may vary from 1·5 to 2·8 times the spore-level, the 'average' cell in an asynchronous population would contain approximately twice the spore amount of deoxyribonucleic acid[12,18]. Furthermore, the average amount of acid per spore has been found to be remarkably constant for any given species and not altered by variations in the composition of the growth medium[19].

A slight decrease in synthesis of deoxyribonucleic acid during the period of cell division is indicated by the results obtained from samples taken at 10-min. intervals (Fig. 1). The slope of the rise of deoxyribonucleic acid before the first division is 1·4, while after the division it is 1·8 (Fig. 1). A more pronounced decline in the rate of synthesis of deoxyribonucleic acid was encountered during the second division when another sampling, 5 min. after the 100 min., was possible.

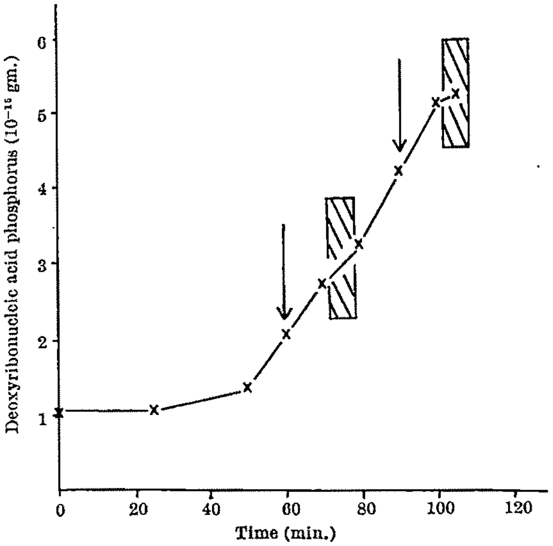

Fig. 1. Deoxyribonucleic acid-phosphorus expressed on the basis of the initial spore count, during the synchronous growth of *B. cereus* from spores through two cell divisions (hatched areas). The arrows indicate the period when each cell contained two fully separated chromatin bodies and twice the spore content of deoxyribonucleic acid

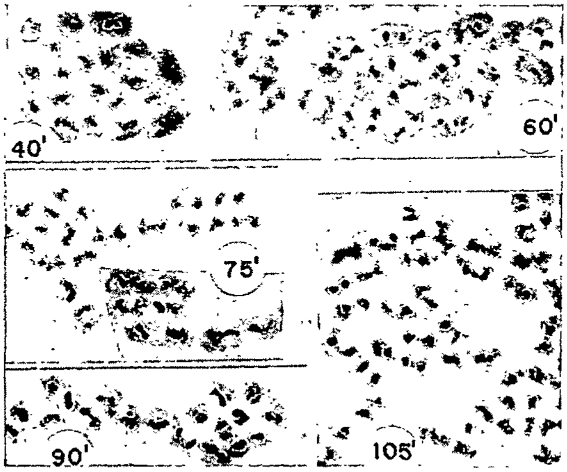

Fig. 2. Changes in nuclear morphology during synchronous growth of *B. cereus* out of germinated spores. Osmium-fixed smears, azure *A*–Feulgen. By 40 min. the spore coats still cover the growing cells but the single nuclear bodies have begun to elongate. At 60 min. the deoxyribonucleic acid has doubled and each cell in proper focus shows two separated nuclear bodies; shed spore coats are also present. By 75 min. the first cell division is proceeding and each nuclear structure is growing into two again. By 90 min. each daughter cell once more contains two separated nuclear bodies, and by 105 min. the second division is under way with the nuclear bodies partly separated like those at 75 min. (× *c.* 2,700)

Cohen's[7] studies with a thymine-requiring *E. coli* synchronized by starvation and replenishment of thymine suggested that doubling of the deoxyribonucleic acid occurred prior to cell division and that during division synthesis of the acid ceased. Lark and Maaløe[2] found that in heat-treated cultures of *S. typhimurium* doubling of the acid was followed by nuclear division. However, in contrast to the findings of Cohen[7], cell division overlapped the period of synthesis of deoxyribonucleic acid. The results reported here, in which synchrony is achieved without recourse to artificial treatment, indicate that during the growth-cycle, synthesis of deoxyribonucleic acid is continuous between, but diminished in rate during, cell division.

The work was supported by a grant from the National Research Council of Canada.

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THE MYOGLOBIN MOLECULE

By DR. HELEN SCOULOUDI

Davy Faraday Research Laboratory, Royal Institution, London, W.1

KENDREW and others[1] have listed a number of forms of myoglobin crystals from aquatic animals, which have a large proportion of this protein in their muscles. These crystalline forms were studied by the methods of X-ray analysis. In a recent paper[2], a three-dimensional solution of the molecular form of myoglobin in type *A* crystals from sperm-whale to a resolution of 6 A. is described. The X-ray analysis provides a map of the electron density in the crystal, and continuous chains of high density can be traced which presumably represent coiled-up polypeptide chains, probably one to each molecule. A disk-shaped region of especially high density is identified with the haem group. The molecules so outlined are separated by extended regions of uniform density which must be attributed to the liquid in the intermolecular spaces. This form of the convoluted chain is illustrated in Fig. 2 of Kendrew's paper[2].

I have been engaged on an X-ray study of myoglobin from the common seal (*Phoca vitulina*), first characterized by Kendrew and others[1] as type *C*. This forms monoclinic crystals, space group $A2$, $a = 57\cdot9$ A., $b = 29\cdot6$ A., $c = 106\cdot4$ A., $\beta = 102°\ 15'$, with four molecules per unit cell. The method of isomorphous replacement introduced by Perutz[3] has been used, the attached heavy-atom groups being $AuCl_4'$, HgI_4'' and *p* - chloro - mercuri - benzene sulphonate. These groups were introduced by methods analogous to those used by Kendrew and others[2] in type *A*. A two-dimensional projection of the crystal density on the *b*-plane has been obtained to a resolution of 4 A., and is shown in Fig. 1.

The present communication describes an attempt to explain Fig. 1 in terms of Kendrew's three-dimensional model. If the myoglobin molecule from sperm-whale is closely similar to the myoglobin molecule from seal, it should be possible to take the sperm-whale myoglobin molecule, re-orientate it in a suitable way, project its density on to a plane, and obtain a match with the density map of Fig. 1. Allowance must, of course, be made for the overlap of neighbouring molecules. As will be shown, it is possible to make this comparison and the fit is remarkably good.

I have been guided in making the comparison by two features of the molecule. In the first place, the Fourier map in Fig. 1 shows regions of high density marked *H*, and there is a strong *a priori* probability that these are the haem groups. In the second place, the results of Ingram and others[4], based on electron spin resonance methods, indicate the orientations of the normals to the haem groups in both the sperm-whale and seal myoglobin crystals. In searching for the right direction in which to make the projection, one therefore has a fixed point in both molecules, the haem group, and these must be brought into superposition. The normals to these haem groups must also be brought into alignment, so that the only variable left is the angle through which the molecule must be turned around the haem-group normal.

A first approximation to the correct orientation was made with the help of a solid model like that shown in the paper by Kendrew *et al.*[2]. Several orientations for the model were tried and in each case the total

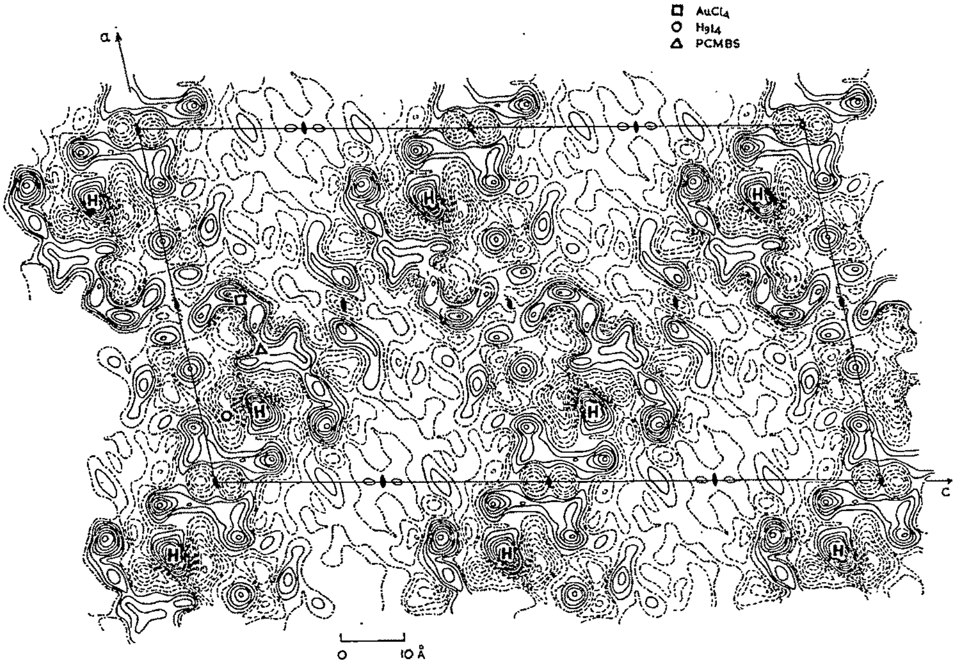
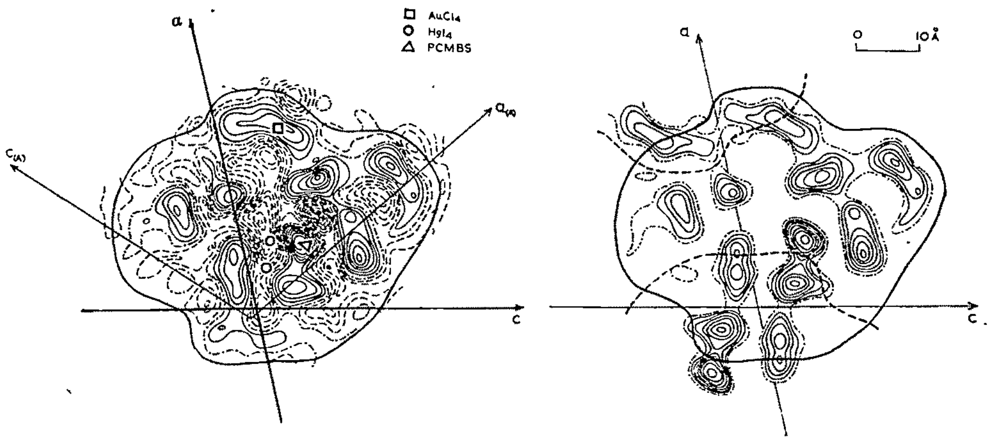


Fig. 1. Projection on the *b*-plane of the electron density distribution in the cell of seal myoglobin, seen at a resolution of 4 A. □, $AuCl_4$; ○, HgI_4; △, *p*-chloro-mercuri-benzene sulphonate



(a) (b)

Fig. 2. (*a*) Single molecule of sperm-whale myoglobin projected on to the *b*-plane of seal myoglobin ; (*b*) the projected molecule with overlap from the molecules related by the screw axes

thickness of chain as shown in that figure was projected on to a plane. When a promising approximate match to Fig. 1 was obtained, it was further explored by summing up the actual electron densities in the appropriate direction. A detailed description will appear elsewhere.

Fig. 2 (*a*) shows this summation for a single molecule projected in a direction which was found to give the best agreement. The axes of the seal myoglobin crystal are shown as heavy lines, the projected axes of the sperm-whale myoglobin crystal as light lines. In the cell of the seal myoglobin crystals there are screw axes at $a = 0$, $c = 0$; $a = \frac{1}{2}$, $c = 0$; $a = 0$, $c = \frac{1}{2}$, $a = \frac{1}{2}$, $c = \frac{1}{2}$; so to compare the results one must allow for the fact that two molecules, related by a screw axis, will overlap. The superposition is shown in Fig. 2 (*b*), where for simplicity contours of positive density have alone been drawn, and the outline of the molecule as deduced by Kendrew is indicated. Fig. 3 is another version of Fig. 1, the *b*-axis projection of seal myoglobin. In this version, only terms to a resolution of 6 A. have been included, and only positive contours drawn, so as to make the comparison with Kendrew's results more direct.

The correspondence is remarkably close, as will be seen by comparing Fig. 2 (*b*) and Fig. 3. The outlines of the molecules are drawn to facilitate the comparison. All the high-density features obtained by projecting Kendrew's solution are faithfully reproduced in the *b*-projection of the seal myoglobin crystal. The haem groups, seen edgewise in the projection, appear as dense regions in corresponding places. Further, the Au and HgI_4 group used in both analyses lie in corresponding positions in the two projections, Fig. 2 (*a*) and Fig. 1, indicating that they are attached to the protein molecules at the same points. (This is not true, however, of *p*-chloromercuri-benzene sulphonate, but there is some

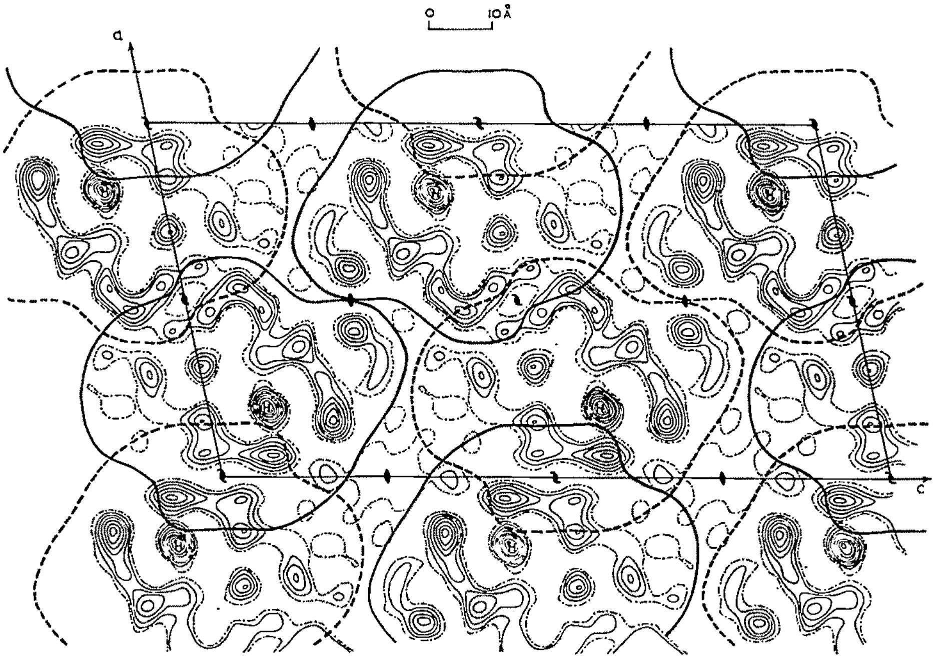


Fig. 3. Electron density projection of seal myoglobin seen at a resolution of 6 A.

evidence that this group is retained in the lattice interstitially, so that its position depends on the molecular packing and is, therefore, different in different forms.)

This correspondence would appear to prove: (*a*) that the two-dimensional Fourier projection of Fig. 1 is nearly correct; (*b*) that the myoglobin molecules in two different species, seal and sperm-whale, are closely similar in general configuration even though their amino-acid compositions are known to differ in details; (*c*) that the outline of the molecule deduced by Kendrew is very nearly right, because there could not be so close a fit if it had been incorrectly traced and included portions of neighbouring molecules.

I wish to thank Sir Lawrence Bragg for his continuous interest and encouragement; Dr. J. C. Kendrew for allowing me to use his results and for his advice throughout this work; Dr. D. C. Phillips for much help and discussions; and Dr. V. C. Shore for assistance with some of the calculations. I am indebted to the Mathematical Laboratory, University of Cambridge, for computing facilities on the EDSAC.

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EFFECTS OF GAMMA-RADIATION ON SOME CARBOHYDRATES, HYDROXYACIDS AND AMINO-ACIDS IN AQUEOUS SOLUTIONS

By DR. S. A. BARKER, DR. P. M. GRANT, PROF. M. STACEY, F.R.S., and DR. R. B. WARD
Department of Chemistry, University of Birmingham

IN an investigation of the effect of γ-radiation from a 200-c. cobalt-60 source on dilute (0·1 per cent) aqueous solutions of some carbohydrates, hydroxyacids and amino-acids we have found that in the absence of oxygen (that is, *in vacuo* or under nitrogen), radicals[1] derived from these compounds exhibit a strong tendency to dimerize (irradiation dose $5·5 \times 10^{19}$ eV. ml.$^{-1}$) and that prolonged irradiation produces polymeric materials. Acidic non-dialysable polymers have been isolated (see Table 1), which

Table 1. IRRADIATION OF CARBOHYDRATES, HYDROXY- AND AMINO-ACIDS IN AQUEOUS SOLUTION

Solute irradiated	Conditions	Polymer formation indicated by dialysis	Polymer formation indicated by cetavlon	Other compounds formed, remarks, etc.	Periodic acid treatment (see text)
Maltose	Vacuum	Yes	Yes	Glucose, gluconic acid, maltobionic acid, *et al.*	
Glucose	Vacuum	Yes	Yes	Gluconic acid, 2-oxo-D-arabino-aldohexose, 2-oxo-D-arabino-hexonic acid, arabinose, *et al.*	
	Oxygen	No	No	Gluconic acid, *et al.*	
	Nitrogen	Yes	Yes	As vacuum system	
Glycollic acid	Vacuum	Yes	Yes	Glyoxylic, tartaric, oxalic and formic acids, formaldehyde and CO_2	Yes
	Oxygen	No	No	As for vacuum system, but only traces of tartaric acid	
Glyoxylic acid	Vacuum	—	—	Oxalic acid, reducing acidic dimer and trimer. Dimer may be dihydroxytartaric acid	Yes
	Oxygen	—	—	Oxalic acid, no other non-volatile products detected	
Tartaric acid	Vacuum	—	—	Non-acidic reducing compound with $R_T = 1·6$, reducing material with $R_T = 1$. Main product had $R_T = 0·3$, $M_T = 1·0$ ('dimer' ?)	Yes
	Oxygen	—	—	Mesoxalic acid, glyoxylic acid, considerable reducing material with $R_T = 1$	Yes
Oxalic acid	Vacuum	—	—	Small amounts of a reducing compound formed, having $R_T = 0·6$	
	Oxygen	—	—	Considerable loss of oxalic acid, but no other non-volatile compounds detected	
Lactic acid	Vacuum	Yes	Yes	Not examined	
Gluconic acid	Vacuum	Yes	Yes	Arabinose, arabonic acid, *et al.*	
Mandelic acid	Vacuum	?	?	Heavy precipitation from aqueous solution, CO_2 formed. Precipitate contains C_6H_5. and .COOH groups	
Formic acid	Vacuum	—	—	Mesoxalic acid, dihydroxytartaric acid and probably tartaric acid. Streaking between $R_T = 0$ and $1·5$	Yes*
	Oxygen	—	—	No non-volatile products	
Glycerol	Vacuum	—	—	Glyceraldehyde, glyceric acid, at least two non-reducing compounds behaving as hexitols. Traces non-reducing acids	
Glycollic acid and glyoxylic acids†	Vacuum	—	—	Dihydroxytartaric acid. Slight uptake of bromine water, suggesting some dihydroxymaleic acid	
Glycollic† and tartaric acids	Vacuum	—	—	Glyoxylic acid, slightly reducing acidic component with $R_T = 0·7$, suggesting a 6-C co-dimer. Reducing compounds with $R_T = 1$.	
Glyoxylic† and tartaric acids	Vacuum	—	—	As for glycollic and tartaric acids system, but more reducing compounds at $R_T = 1$ and $0·7$	
Glycerol and glyceraldehyde†	Vacuum	—	—	Hexonic acids, small amounts of glyceric acid. Hexose production uncertain	
Glycerol and 1 : 3-dihydroxyacetone†	Vacuum	— —	—	As for glycerol and glyceraldehyde system. Ketohexose production doubtful	
Glycine	Vacuum	—	Yes	Compounds or compound with $R_{\text{glycine}} = 0·5$ detected with ninhydrin and alkaline silver nitrate	
	Oxygen	—	No	No compounds with $R_{\text{glycine}} < 1$	
Alanine	Vacuum	—	Yes	Not examined	
Phenylalanine	Vacuum	—	Yes	Not examined. No precipitation, but the freeze-dried solute was only sparingly (0·2 per cent) soluble in water (cf. mandelic acid)	

* Forms glyoxylic and oxalic acids.

† Indicates the component in mixed systems which was the more readily destroyed by radiation.

gave precipitates with 2 per cent 'Cetavlon' solution[2], the precipitates being soluble in M sodium chloride. The presence of oxygen drastically reduced dimerization, and no polymers were then detected. Instead, oxidation products were formed by processes which involved considerable C—C bond scission and decarboxylation. These effects can be readily explained by the radicals initially produced from the solvent causing hydrogen abstraction from the organic solute, thereby forming an organic radical[3]. *In vacuo* or under an atmosphere of nitrogen these radicals may join together or undergo saturation by the addition of a solvent radical. In the presence of oxygen, the gas readily adds on to the organic radical to yield a peroxy-radical, which may react with radicals[4] present in the system to yield a molecule in which, ultimately, a hydroxy group has been substituted on to the site of the original hydrogen abstraction.

The emphasis in this work has been on the radical addition reactions occurring *in vacuo*, including reactions occurring in solutions containing more than one solute when dimers are formed by linking of the various radicals. The glucose and glycollic acid systems have been examined, and in the latter case a complete mass balance in the presence and absence of oxygen has been obtained[1]. Polymeric materials have been isolated as indicated, but the evidence for compound formation is based on chromatographic and ionophoretic analysis. The mobility values quoted, R_T and M_T, are the chromatographic (propionic acid/n-butanol/water—3 : 6 : 4 v/v) and ionophoretic (0·2 M acetate buffer, pH 5·0) mobility values respectively, relative to tartaric acid. The spray reagents used were aniline hydrogen phthalate[5] (reducing sugars), alkaline silver nitrate[6], and chlorophenol red[7] (acidic groups). In addition, in some cases the solute mixture, after being spotted on to the paper, was treated with a spot of 5 per cent periodic acid pentahydrate solution before irrigation and subsequent spraying[8]. This method causes tartaric acid to yield glyoxylic acid and dihydroxytartaric acid to yield oxalic acid, etc. In the amino-acid systems, the chromatograms were sprayed with ninhydrin[9] and alkaline silver nitrate[6], and the mobilities expressed as R_{glycine} relative to glycine using the propionic acid/n-butanol/water solvent.

The results are shown briefly in Table 1, and indicate the potentials of mixed solute irradiations in vacuum for forming radical addition products, and the readiness with which polymers can be formed. It is hoped that further work will elucidate more thoroughly the structure of the polymers and the addition compounds formed.

We wish to thank the U.K. Atomic Energy Authority, Research Group, Harwell, for supporting the investigation and for maintenance grants.

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SOME SOUTH AFRICAN STONE AGE CULTURES

By Dr. R. J. MASON

Archæological Survey of the Union of South Africa

Statistical Analysis of the South African Later Chelles-Acheul and Earlier Fauresmith Cultures

In South Africa our knowledge of the Earlier Stone Age is based on pioneer work that yielded the framework of stratigraphy and broad typo-technological outline of the main prehistoric cultures. Pioneer research regarded the Fauresmith Culture as well separated typologically, technologically and stratigraphically from its ancestor, the Chelles-Acheul. In the Vaal River Basin the South African Chelles-Acheul Stages III–V industries, here described as Later Chelles-Acheul, are found in the later aggradations of the Younger Gravels and overlying calcified sands with a predominantly Middle Pleistocene fauna[1], while the Earlier Fauresmith lies on the surface of the calcified sands and in the Youngest Gravels of the Vaal tributaries[2].

Recent excavations at two Transvaal sites, the Cave of Hearths near Potgietersrus and Wonderboom near Pretoria, have yielded important Earlier Stone Age industries originally classified as Later Chelles Acheul on a non-statistical basis[3,4]. Subsequent study of the Cave of Hearths Earlier Stone Age fauna showed it to be of Later Pleistocene age (Cooke, H. B. S., personal communication), that is, considerably more recent than the Vaal Chelles-Acheul fauna. Industries similar to the Cave of Hearths Earlier Stone Age were found in Later Pleistocene gravels at open sites near the cave. This dating evidence, apparently conflicting with the typology of the industries, led to a detailed statistical study of both the Cave of Hearths and Wonderboom industries, which were statistically compared with Later Chelles-Acheul industries from Vaal Middle Pleistocene gravels at Riverview Estates and Canteen Koppie. It was then found that, despite very close overall resemblances in typology and technology, the Vaal Later Chelles-Acheul and Wonderboom–Cave of Hearths series could be statistically separated, in terms of hand-axe length–width proportions and proportions of dorsally prepared quadrilateral flakes. A Later Pleistocene gravel series from Rooiberg, geographically situated between Wonderboom and Cave of Hearths, was found to have the same statistical characters as those from the latter two sites. Clearly these three industries, all originally classified in non-statistical terms as Later Chelles-Acheul, must be re-classified as Earlier Fauresmith, a culture probably less than half the age of the Later Chelles-Acheul.

Hand-axe length–width proportions. The use of this index in the South African context was suggested by McBurney's distinction between European Acheul and Mousterian hand-axes[5].

In the latter valuable study, McBurney was able to show that Acheul hand-axes were considerably narrower than Mousterian specimens, the Acheul length–width percentage varying from 57·38 to 61·53, while the Mousterian percentage ranges from 69·40 to 77·27.

The South African percentages are as given in Table 1.

Table 1. HAND-AXE LENGTH–WIDTH PERCENTAGES

Culture	No. of observations	Average length–width (per cent)
VAAL LATER CHELLES–ACHEUL		
Riverview Estates Younger Gravels	56	54
TRANSVAAL EARLIER FAURESMITH		
Cave of Hearths Bed 3	62	65
Wonderboom	52	65
Rooiberg Youngest Gravels Earlier Group	45	58
Rooiberg Youngest Gravels Later Group	30	63

These figures indicate that the Vaal Later Chelles–Acheul hand-axes, typologically very similar to Transvaal Earlier Fauresmith, are nevertheless narrower, at the sites listed, just as European Acheul hand-axes appear to be narrower than Mousterian hand-axes.

Quadrilateral flakes with prepared dorsal surfaces. The term 'quadrilateral flake' has been defined[6], and refers to flakes having a quadrilateral plan view. Quadrilateral flakes, like all flakes, may owe their shape either to deliberate or haphazard preparation of the dorsal surface. In Western Europe flakes with deliberately prepared dorsals are called 'Levallois' flakes, a term discontinued in Southern Africa following a decision by the Pan-African Congress of Prehistory in 1947[7]. The latter decision apparently confused the Levallois technique of dorsal preparation with the faceted platform technique, which is not necessarily an aspect of the Levallois technique.

Table 2. DORSALLY PREPARED QUADRILATERAL FLAKE PERCENTAGES

Culture	Total	Percentage dorsally prepared
VAAL LATER CHELLES–ACHEUL		
Canteen Koppie Younger Gravels	46	19
TRANSVAAL EARLIER FAURESMITH		
Cave of Hearths Bed 3	225	48
Wonderboom	63	61
Rooiberg Youngest Gravels Earlier Group	39	56

The figures (Table 2) indicate a more extensive use of dorsal preparation technique in the Transvaal Earlier Fauresmith than the Vaal Later Chelles–Acheul, at the sites listed. The Rooiberg Youngest Gravels Later Group quadrilateral flake sample is too small for inclusion in Table 2.

Some differences in length dimensions of the hand-axe and quadrilateral flake classes in the Vaal Later Chelles–Acheul and Transvaal Earlier Fauresmith samples available may be seen, but these will be set out elsewhere with the full account of the investigation summarized in the present article.

Two main considerations emerge from this preliminary study. It is suggested that the Fauresmith Culture of the type area, Western Orange Free State and Northern Cape, has been defined on the basis of a late stage more clearly distinct from the Chelles–Acheul than its earlier stage as seen in the Transvaal. A broader definition of the Fauresmith Culture, on a statistical basis, is indicated. Secondly, the weakness of a non-statistical classification which failed to distinguish industries similar in typology and technology, but immensely different in age, has been shown, emphasizing the importance of statistical analysis in prehistory.

Parallels between the French Mousterian and Transvaal Earlier Fauresmith Cultures

GOODWIN, in his original description of the Fauresmith Industry, noted the presence of a flake element showing close resemblances to the French Mousterian, which he attributed to the arrival of Mousterian influences in South Africa[8]. Burkitt[9] also directed attention to such similarities, and later workers have repeated these views. Both Goodwin and Burkitt based their opinions on material from the Fauresmith type area, namely, the Northern Cape and Western Orange Free State. Later, the Fauresmith Culture was recognized beyond the confines of the type area, while recent excavations in the Cave of Hearths in the Makapan Valley and Wonderboom near Pretoria have given adequate material for detailed examination of the culture in the Transvaal. No detailed comparison of the Fauresmith and French Mousterian was made until 1956, when I was able to carry out a brief comparative study generously financed by the Wenner Gren Foundation for Anthropological Research.

Intercontinental dating comparisons of Stone Age cultures are insecure, but it is significant that the French Mousterian culture falls within the European Upper Pleistocene[10], while the Earlier Transvaal Fauresmith belongs to the local Later Pleistocene, as seen in the Makapansgat Cave of Hearths fauna (Cooke, Dr. H. B. S., personal communication), suggesting a broadly equivalent position in the world time-scale. F. Bordes[11] observes at least six variants within the French Mousterian group, of which only two concern us here, the 'typical' Mousterian and Mousterian of Acheulean tradition. The typical Mousterian appears to be a variant of the Mousterian of Acheulean tradition, its typology consisting of similar flake classes without the higher proportion of hand-axes and cleavers found in the latter industry. Both industries are frequently found in different beds at the same site, such as Le Moustier and Abri Brouillard in the Dordogne.

With the kind permission of Mr. Harper Kelley, I was able to study the Abri Brouillard industries in the Musée de l'Homme, Paris. Peyroney and Bourrinet excavated Abri Brouillard in 1907, finding two superposed Mousterian beds overlain by a thin 'Aurignacian' horizon[12]. The large number of irregular artefacts and waste fragments in the series suggests that it is reasonably representative, unlike most early collections. The Bed 1 industry may be classified as typical Mousterian and that from Bed 2 as Mousterian of Acheulean tradition, with a high proportion of denticulate flakes in both industries. A number of close typological and technological similarities were seen in comparing the Mousterian of Acheulean tradition Bed 2 industry from Abri Brouillard and the Transvaal Earlier Fauresmith industry from Cave of Hearths Bed 3, on a statistical basis. The detailed comparisons will be published elsewhere ("Cave of Hearths", monograph in preparation). Here we are concerned only with main features. The 'typical' Mousterian industry of Abri Brouillard Bed 1 is similar to the Bed 2 series but has a lower proportion of bifaced hand-axes and cleavers, as shown in Table 3.

Table 3. FRENCH MOUSTERIAN

Site	Hand-axes and cleavers (per cent)	Flakes (per cent)	Total
Brouillard Bed 1	1	99	527
Brouillard Bed 2	27	73	481

The reason for the variable class proportions is unknown, but might be response to differing seasonal needs.

A similar position is seen in the Transvaal Wonderboom and Cave of Hearths Bed 3 series, now classified as Transvaal Earlier Fauresmith (see preceding communication). The Wonderboom series consists of the same hand-axe, cleaver and flake classes found in Cave of Hearths Bed 3; but the flake classes are predominant, as in the 'typical' Mousterian of France (Table 4).

Table 4. TRANSVAAL FAURESMITH

Site	Hand-axes and cleavers (per cent)	Flakes (per cent)	Total
Wonderboom 76–79 in.	4	96	242
Wonderboom 39–42 in.	2	98	285
Wonderboom 6–18 in.	0·3	99·7	366
Cave of Hearths Bed 3	20	80	1,083

At Wonderboom we have the first evidence in Africa for the existence of a Fauresmith parallel to the French Typical Mousterian industry. Comparison of the Abri Brouillard, Cave of Hearths and Wonderboom industries shows not only general typo-technological resemblances but also similar variable production of the flake component in the Transvaal Fauresmith, French Typical Mousterian and Mousterian of Acheulean tradition cultures. While earlier comparisons were with the Mousterian in general, Wonderboom enables us to compare the Transvaal Fauresmith more specifically with the French *Mousterien typique*.

The Cave of Hearths Earlier Stone Age industries, best represented in Bed 3 at that site, were originally classified as Later Chelles–Acheul. The later Pleistocene fauna afterwards found with these Earlier Stone Age industries, among other factors, showed that they could not possibly be the same age as the Later Chelles–Acheul which, both on the Vaal River and in East Africa, is associated with a fauna of more archaic aspect. Subsequent statistical study showed that despite the close general resemblances of the Cave of Hearths Earlier Stone Age series and the Vaal Chelles–Acheul, they could be separated from the latter industries in statistical terms (see preceding communication). Statistical study of the Wonderboom series showed its close resemblances to the Cave of Hearts Bed 3 industry, in all except class proportions, forcing me to change my 1957 non-statistical classification of Wonderboom[13] as a Later Chelles–Acheul site and assign the entire series to the Transvaal Fauresmith culture. For these reasons I have come to suspect non-statistical classifications of Acheul industries found elsewhere, such as the 'Upper Acheul' industries from Mount Carmel[14] and Jabrud[15] in the Eastern Mediterranean area. Like the Wonderboom and Cave of Hearths Earlier Stone Age industries, these 'Acheul' series might prove to be considerably later than their non-statistical classification indicates. They may prove to be Eastern Mediterranean parallels of the French Mousterian of Acheulean tradition. At Jabrud Site 1, the 'Acheul' beds are intercalated with flake industries said by d'A. Waechter[16] to be "Acheulean without hand-axes", in my view, possibly the same as Typical Mousterian, though Bordes, who has studied the Jabrud series in detail, describes the Jabrudien as an eastern facies of the la Quina Mousterian[17].

So we are confronted with a curious dualism in Acheul derivative cultures spread from France, possibly to the eastern Mediterranean and appearing unexpectedly on the southern end of Africa at Wonderboom and Cave of Hearths. The racial type found with the French Mousterian is Neanderthal, while the Fauresmith horizon in Cave of Hearths Bed 3 yielded a jaw fragment tentatively classified as Neanderthal[18].

There can be little doubt that for the most part evolution in the South African Stone Age continues undisturbed from the very beginnings of the Stone Age until its end, with occasional migrations from neighbouring parts of Africa accounting for intrusive cultures such as the Smithfield and Sangoan, both the latter derived from the Congo. The unbroken nature of the culture sequence disproves claims for a 'Mousterian' invasion from the north, but does little to account for the Fauresmith–Mousterian parallels indicated in the present article. For the present, these widely separated racial and cultural resemblances, occurring in radically different ecological settings, must be regarded as an enigma, unless they are explained by derivation from a single source followed by evolution in isolation during an immensely long period of time. The preservation of genetic and cultural similarities could have been due to an unexplained biological and psychological conservatism.

Acknowledgments are due to the Wenner-Gren Foundation for Anthropological Research, the generous financial support of which made possible part of the research summarized in this article. Discussion with Mr. B. D. Malan, director of the Archæological Survey, led to modification of the views given here.

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LETTERS TO THE EDITORS

OCEANOGRAPHY

Measurements of the Pacific Equatorial Countercurrent

As part of *Doldrums*, the third of three International Geophysical Year oceanographical expeditions of the Scripps Institution of Oceanography, direct current measurements were made in the centre of the equatorial countercurrent, 7° 52′ N., 107° 30′ W. The techniques were similar to those used three months previously, when measurements were made of the Cromwell current at the equator, 140° W.[1]. In the top 300 m. observations were made by suspending a propeller-type current meter (a modified Roberts meter) from a drifting ship and measuring the apparent velocity at different depths from the flow of water past the meter while at the same time observing by radar the drift of the ship from a fixed reference point—a taut wire buoy anchored in 2,200 fathoms. Below 300 m. measurements were made by following the drift of Swallow current floats[2].

Calculations of the geostrophic current as well as other considerations have led to a picture of the countercurrent as a shallow current the maximum velocity of which is to be found somewhat below the surface, but the flow of which is confined almost entirely to the region in and above the sharp tropical thermocline. Direct current measurements made on *Doldrums* modify this picture. The highest velocities in the countercurrent are found above the thermocline, and the peak velocity is found beneath the surface but in the mixed layer. However, the countercurrent does not vanish beneath the thermocline but continues to flow east at speeds of 15–20 cm./sec. Fig. 1 is a plot of the east–west current component as measured on *Doldrums*. The current profile above 200 m. is a composite of 12 Roberts meter stations taken over a two-week period; below 200 m. the curve is drawn to the six Swallow current float measurements summarized in Table 1. The depth of the thermocline as measured by the bathythermograph is also shown.

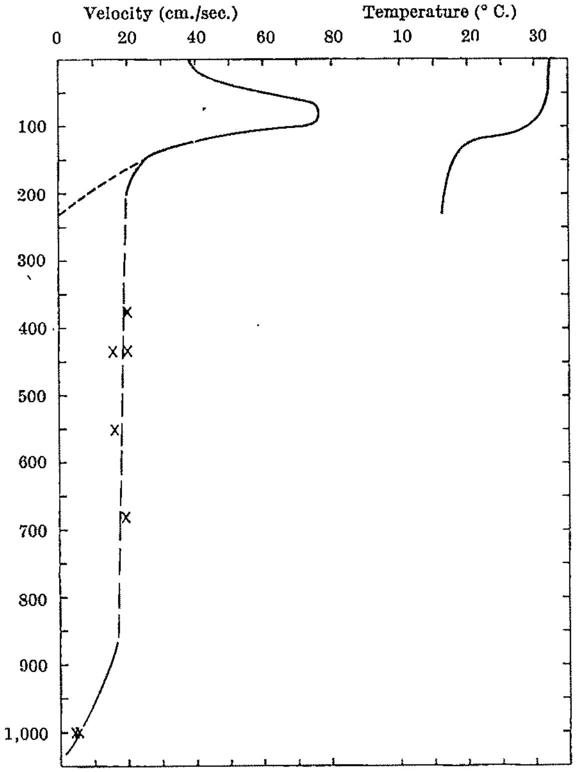

Fig. 1. Current and temperature profile in Pacific equatorial countercurrent, 7° 52′ N., 107° 30′ W. Transport calculation above and below the thermocline were made relative to the dashed line

Table 1

Date	Hours tracked	Depth (m.)	Velocity (cm./sec.) — direction (toward)
August 12	7·2	370	20 — 080°
15	12·5	680	20 — 100°
16	16·0	590	16 — 085°
17	14·2	1,000	5 — 085°
18	7·3	1,000	5 — 135°
26	14·9	430	16 — 115°

The results summarized in Fig. 1 indicate that the countercurrent transports more water below the thermocline than above it. The width of the countercurrent during this period was 250–300 km. Making some allowance for a decrease in the current near its edges a rough estimate of the transport of the countercurrent based on this one profile is 20×10^6 m.^{3}/sec. for the region above the thermocline and 30×10^6 m.^{3}/sec. for that below the thermocline. The estimated transport above the thermocline agrees with that given by Sverdrup[3] for the countercurrent ($20–25 \times 10^6$ m.^{3}/sec.).

The problem of water balance and mass transport in the equatorial Pacific must be re-examined and at least one detailed north–south section of direct current measurement stations is required. The measurements of the Cromwell current in May, 1958, showed[1] an eastward transport of 30×10^6 m.^{3}/sec. The present observations imply that there is an additional transport of 30×10^6 m.^{3}/sec. in the countercurrent below the thermocline. These additions more than triple the total eastward transport in the equatorial Pacific as given by Sverdrup[3].

JOHN A. KNAUSS
ROBERT PEPIN

Scripps Institution of Oceanography,
University of California,
La Jolla, California.
Nov. 21.

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GEOPHYSICS

Geomagnetic Micropulsations

A DETAILED analysis of geomagnetic micropulsations has been carried out on records obtained at Albert Head between November 29, 1956, and February 16, 1957. Albert Head (approximately 48° 23′ N., 123° 29′ W.) is situated by the sea near Victoria, Vancouver Island, British Columbia. The records were obtained from three mutually perpendicular air-core induction coils, each 20 ft. in diameter, mounted in a rigid wooden octahedron[1]. The records were analysed by visual inspection: more than 300 fluctuations were identified with periods ranging from 15 to 400 sec. Their amplitudes were read and reduced by simple computation to components X (north), Y (east) and Z (vertically downwards). Plots were made of these three components against the period T of the oscillations, but yielded little information. There was a tremendous scatter in the points, and it was impossible to draw any mean curve through the data. The only conclusion that could be drawn was that, in general, the amplitude appeared to increase with the period.

The same data were then taken and the amplitude of every fluctuation divided by the K_p index at the time the observation was made. Plots were drawn of X/K_p, Y/K_p and Z/K_p against T. There was a very considerable reduction in the scatter, which was further reduced if local K indices (instead of K_p) were used. A least-squares analysis gave extremely interesting results. The graphs of both X/K_p (Fig. 1) and Y/K_p (Fig. 2) consist of parts of two straight lines—the change of slope occurring at a period of about 2 min. An investigation is now being made to see whether these may represent two different kinds of magnetohydrodynamic waves—poloidal and torsional oscillations. The graph of Z/K_p (Fig. 3) is almost linear. It would be interesting if similar calculations were made at other stations and at different periods of the year. The above method of analysing the data may not be the best, but was continued since the early results were encouraging. The smallest K_p value was 1·0. A detailed account of this study is being prepared.

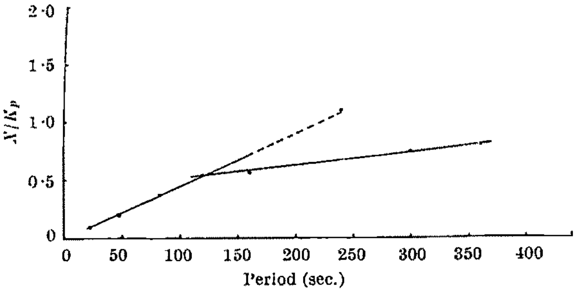

Fig. 1. X/K_p plotted against period (Albert Head, November 1956–February 1957)

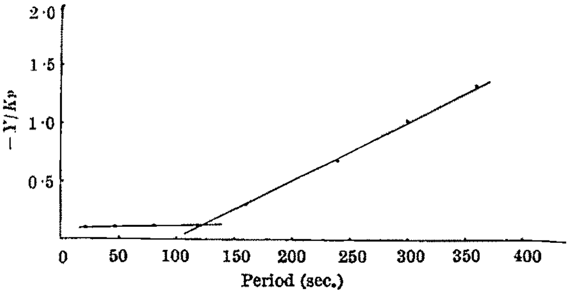

Fig. 2. $-Y/K_p$ plotted against period (Albert Head, November 1956–February 1957)

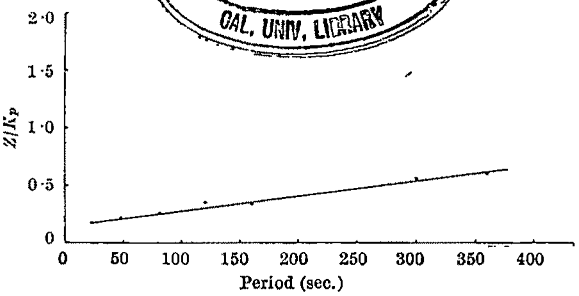

Fig. 3. Z/K_p plotted against period (Albert Head, November 1956–February 1957)

This work is supported by the Defence Research Board of Canada and was carried out last summer at the Pacific Naval Laboratory, Esquimalt, British Columbia.

J. A. JACOBS

Geophysics Laboratory,
University of British Columbia,
Vancouver.
Dec. 13.

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Storm-Time Increase of Cosmic-Ray Intensity

DURING the period of the International Geophysical Year (July 1957–February 1958) there were several occasions in which the intensity of cosmic rays increased by a few per cent. Two typical events, which occurred on September 13, 1957, and February 11, 1958, respectively, will be described here.

Since the change in intensity is complicated by the diurnal variation, the world-wide type of decrease and so on, the increases observed at any particular position may be depressed or exaggerated. In order to study the characteristics of an increase more clearly, Fig. 1 was prepared. The four curves represent the variation in intensity averaged for two or three stations distributed symmetrically in geographical longitude (Table 1), so that any diurnal variations may be approximately smoothed out[1]. From Fig. 1 it is seen that the cosmic-ray intensities increased

Table 1. STATIONS USED IN COMPILATION OF DATA FOR FIG. 1

Symbol	Component	Station	Altitude (m.)	Geomagnetic latitude	Geographical longitude
I_1	Neutron	Norikura	2,770	25·6° N.	137·6° E.
	,,	Zugspitze	2,960	48·2° N.	11·0° E.
	,,	Climax	3,400	48·2° N.	106·2° W.
I_2	,,	Yakutsk	S.L.	51·0° N.	129·6° E.
	,,	Göttingen	273	52·3° N.	9·9° E.
	,,	Chicago	S.L.	52·6° N.	87·7° W.
I_3	,,	Mawson	S.L.	73·1° S.	62·9° E.
	,,	Resolute	S.L.	82·9° N.	94·9° W.
I_4	Meson (ion chamber)	Yakutsk	S.L.	51·0° N.	129·6° E.
	,,	Moscow	S.L.	50·8° N.	37·3° E.
	,,	Fredericksburg	S.L.	50·0° N.	76·7° W.
H	Geomagnetic horizontal	Kakioka	S.L.	26·0° N.	140·2° E.
K_p	K_p index				

S.L., sea-level

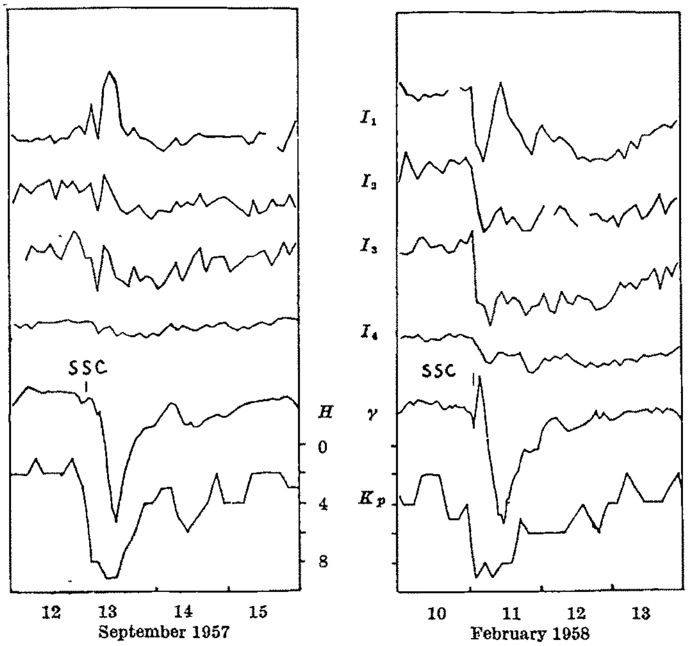

Fig. 1. World-wide variations of cosmic-ray intensities obtained by averaging data from the station in Table 1, and the change of magnetic activity

abruptly by about 2 or 3 per cent on a world-wide scale regardless of diurnal variation. (This does not exclude the possibility of the longitude variation of increment.) The times of maximum intensities were 9 hr. ± 1 hr. on September 13 and 11 hr. ± 1 hr. on February 11, respectively.

The variations of horizontal magnetic force observed at Kakioka as well as the international magnetic activity index (K_p), are also plotted in Fig. 1. It was found that the increase in intensity of the cosmic rays coincided with the severest phase of magnetic storms. The magnetic storm in February was one of the severest in recent years, and that in September was almost as severe. Many magnetic observatories reported a K_p index of 9 for the interval containing the cosmic-ray increase in each storm. It is of interest that, during these storms, auroræ were seen in such low latitudes as those of Japan[2].

Large solar flares, which appear to be the cause of these storms, occurred at 02h. 45m. on September 11, and at 21h. 08m. on February 9, respectively; none was seen before or during the actual time of the increases. These increases, therefore, seemed to differ from the so-called extraordinary increases of cosmic rays, a fact that is confirmed by the mode of variation in latitude shown in Fig. 2. Usually, the solar cosmic rays predominate in higher latitudes, but the increases described here were most pronounced in lower latitudes.

The variation with latitude of the increment in Fig. 2 may be outlined as follows: the increment increases slightly with the latitude from the equator to about 50° N.; it then decreases steeply, and reaches a constant level which is rather difficult to evaluate, however, because of the process of normalization.

In order to illustrate the dependence upon energy of the increments, a comparison in variational amounts of the increase and decrease was made as shown in Fig. 3. The increment seems to be proportional to the amount of decrease, which is itself a function of altitude and component. Since the stations chosen lie in the region of latitude lower than 50° N., it may be said that the dependence upon energy of the cosmic-ray increase is nearly the same as that of the decrease.

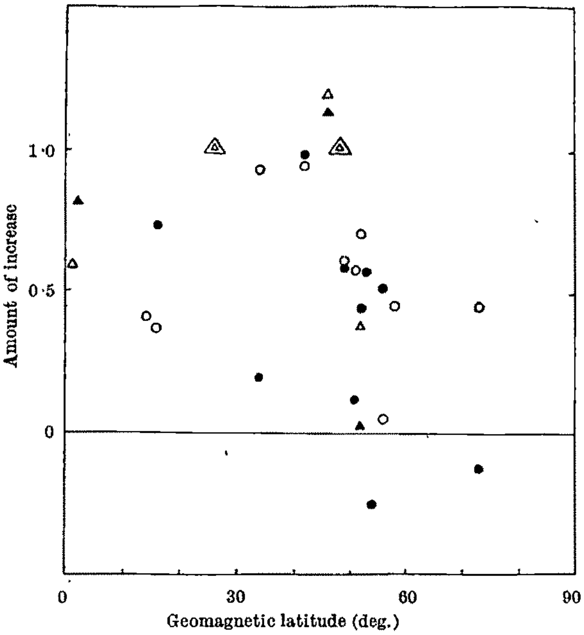

Fig. 2. Variation with latitude of the cosmic-ray increment. Each increment is calculated as the difference in intensity between the time of the increase (6 hr. around each maximum) and 6 hr. before and after the increase. An adjustment has been made to eliminate dependence on longitude. Because the increases were less significant, results for American regions are omitted. Circles, sea-level stations; triangles, mountain stations; ○ and △, September; ● and ▲, February. Double triangles, stations for I_1 in Fig. 1 which were used as normalization points

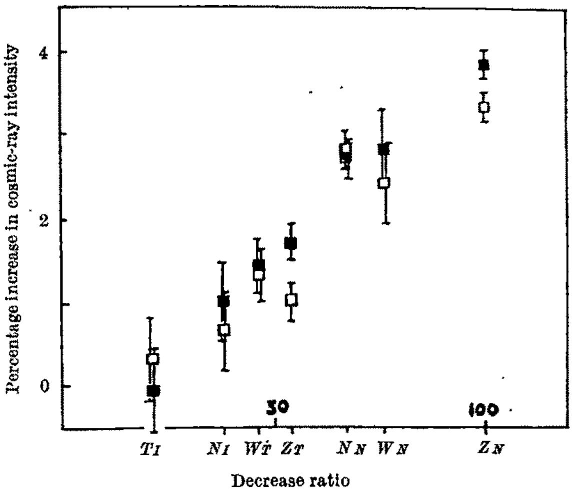

Fig. 3. Quantitative relation between the world-wide decrease and increase of cosmic-ray intensity. The scale for the abscissa was obtained by averaging the amounts of decreases occurring during 1957 at corresponding stations using the apparatus indicated, with an estimated error of approximately 3 on the scale. Abbreviations: Z, Zugspitze; W, Weissenau; N, Norikura; and T, Tokyo. Subscripts: N, neutron; T, meson monitor; and I, ion chamber. The errors in ordinate are the statistical values. The zero line of the ordinate is subject to slight adjustment in the calculation of intensity-level

We wish to thank the staffs of the cosmic-ray observatories throughout the world for the results used and Dr. Y. Miyazaki for allowing us to use the data compiled in the World Data Centre of Cosmic Rays in Japan.

SEKIKO YOSHIDA*

Physical Institute,
Nagoya University,
Nagoya.

MASAMI WADA

Institute of Physical and
Chemical Research,
Tokyo.

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* Present address: State University of Iowa, Iowa.

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Occurrence of Giant Travelling Ionospheric Disturbances at Night

A RECENT publication[1] from this laboratory has discussed the existence of large travelling ionospheric disturbances which during winter daylight hours travel from south to north over the east coast of Australia. This type of disturbance first described by Munro and Heisler[2] has been tracked from Hobart to Townsville, a distance of 3,000 km. with no apparent change in amplitude. Moreover, the frontal extent of the phenomenon is at least 1,000 km. and may be greater. Munro[3] found evidence in the northern hemisphere ionosonde records of similar disturbances travelling south during the winter months. This has been confirmed by Wells[4] and verified at Stanford University in a recent report[5] which shows how backscatter techniques have been used to find many examples of giant travelling ionospheric disturbances, some of which have been shown to extend at least from the east to the west coasts of America and to travel distances of 4,000 km.

It was previously thought that this phenomenon was confined to daylight hours, but recently careful investigation of night ionosonde records has revealed anomalies which are obviously a counterpart to the disturbances discussed above.

This phenomenon is characterized by a rapid fall in virtual height of the F-layer accompanied by a reduction in critical frequency; a cusp then appears at the top of the F-layer in the form typical of a daylight record with $F1$ stratification. This stratification then disappears and as a consequence leaves a high F region trace. The layer then slowly falls to its original height. Part of the sequence at a particular ionospheric station is shown in Fig. 1.

These disturbances are infrequent and seldom occur more than once a night or on more than two or three nights a week, and consequently identification on ionosonde records from a number of stations is conclusive. Fig. 1 is a series of tracings showing a disturbance on records from Brisbane (27° 28′ S., 153° 2′ E.), Camden (34° 03′ S., 150° 40′ E.) and Townsville (19° 10′ S., 146° 58′ E.). The difference in time of occurrence at the various stations is obvious and is consistent with a disturbance travelling approximately due east with a speed of 8 km./min. Moreover, since these stations lie in an approximate north–south line the fronts must extend at least from Camden to Townsville, a distance of 1,800 km. A similar disturbance occurring on the Camden record at 2220 hr. on June 26, 1957, has been positively identified at Brisbane and Townsville and was travelling 46° east of north with a speed of 16 km./min. Watheroo (30° 18′ S., 115° 56·6′ E.) record for the same night showed a similar disturbance but with a difference in time which would suggest that the disturbance front was curved with a direction of travel north-west in Western Australia and north-east in Eastern States. Unfortunately, there are no ionospheric stations in the east – west line between Camden and Watheroo, a distance of 3,300 km., to determine this positively.

There are as yet insufficient results to interpret the seasonal variation of occurrence, although examples have been found during March, June and July. Research into the phenomenon is continuing and it is hoped that the discovery of such disturbances in the much simpler ionospheric conditions existing at night may help materially in determining the mechanics of the phenomenon.

Grateful acknowledgment is made to the Ionospheric Prediction Service of the Department of Interior and the Geology and Geophysics Division of the Bureau of Mineral Resources for their co-operation in providing ionosonde records for this research. This work is part of the investigations of the Sydney Laboratory of the Radio Research Board in the

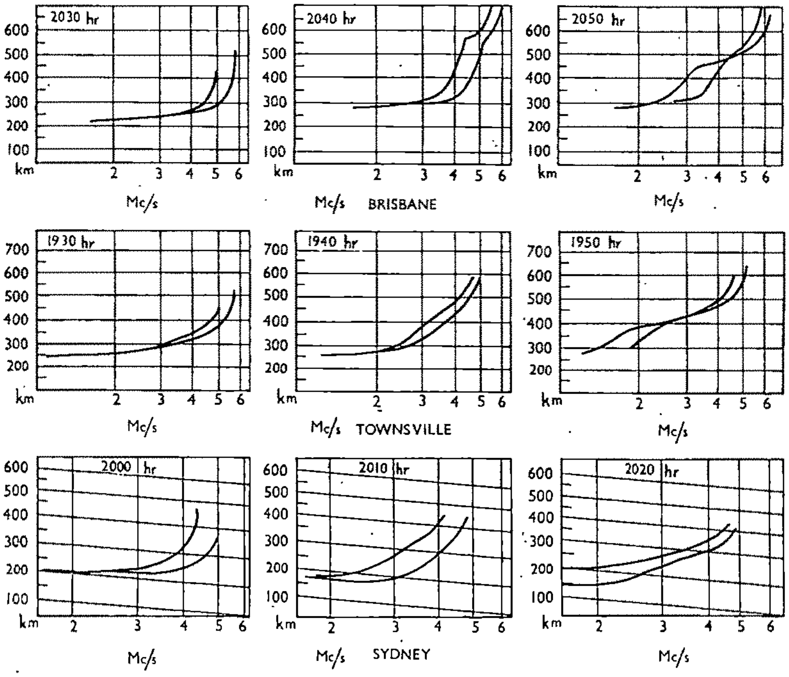

Fig. 1. Tracings of ionosonde records from Brisbane, Townsville and Sydney for July 5, 1957, showing giant travelling ionospheric disturbance. Speed 8 km./min. in a direction 85° E. of N.

Electrical Engineering Department of the University of Sydney.

L. H. HEISLER

Sydney Laboratory,
Radio Research Board, C.S.I.R.O.,
Electrical Engineering Department,
University of Sydney.

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Origin of Upper-Atmosphere Lithium Atoms responsible for the New Twilight Airglow at 6708 A.

A NEW emission line near 6708 A. has been reported recently by Delannoy and Weill[1] to be present on twilight spectrograms obtained in Adélie Land, Antarctica, during October 1957. Gadsden and Salmon[2] also report the appearance of the same line in twilight spectra photographed at Hallett Station, Antarctica, during August, 1958, and at Invercargill, New Zealand, on September 5, 1958. In both instances, the authors attribute the new line to resonance radiation from the 2^2S—2^2P transition in the neutral lithium atom at 6707·8 A.

In a further communication, Barbier, Delannoy and Weill[3] estimate the ratio of the number of neutral atoms of lithium to those of sodium at the level of twilight emission, taking into account the very different energy of the exciting solar radiation at 5893 A., and 6708 A. respectively. From an observed intensity ratio, $I_{6708}/I_{5890+5896}$, equal to 0·1 : 1, they compute an abundance ratio of $N_{\mathrm{Li}}/N_{\mathrm{Na}}$ of $\sim 0{\cdot}006$, about three times greater than that found in stony meteorites[4]. Since the lithium/sodium concentration ratio for oceanic waters[5] is only $\sim 2 \times 10^{-5}$, they conclude that both the sodium and lithium atoms in the high atmosphere are meteoritic, and not terrestrial in origin.

Gadsden and Salmon[2] infer from their intensity ratio measurements an even greater relative concentration of lithium, with a lithium/sodium ratio of $\sim 0{\cdot}05$, or some twenty-five times the expected value if both atoms are derived from meteoritic dust. They report also that altitude measurements of both the normal sodium and lithium twilight radiations revealed that, between August 13 and September 5, the height of the lithium emission (relative to that of sodium) decreased by $\sim 0{\cdot}4$ km. per day, the equivalent of a steady rate of fall of 0·46 cm. per sec. for the 'lithium cloud'.

On inserting this latter value in the classical Stokes's equation, together with the following adopted values for the remaining parameters, namely, air density at 80 km., $2{\cdot}5 \times 10^{-8}$ gm. per cm.^{3}; air viscosity at 190° K., $1{\cdot}2 \times 10^{-4}$ gm. per cm. per sec.; density of meteoritic dust, 3·5 gm. per cm.^{3}, a mean particle diameter of 5·4μ is obtained. According to Öpik[6], this is of the right order of magnitude if the particles in the cloud with which the lithium atoms are associated are derived from micro-meteors.

However, when such an origin is invoked, a major difficulty immediately arises in any attempt to explain the observed differential rate of fall of the lithium emission, since this would not be expected if both lithium and sodium atoms were associated with a falling cloud of meteoritic material.

The above argument, when taken in conjunction with the excess values of the lithium/sodium abundance ratio observed in 1957 and 1958, makes any hypothesis of a meteoritic origin for either element suspect. On the other hand, it lends credence to the recently published statement by the American Committee for the International Geophysical Year[7] that the presence of lithium in the upper atmosphere could be related, as was the recent artificial aurora[8], to nuclear (lithium bomb) explosions detonated at high altitude over the central Pacific Ocean during the period of the International Geophysical Year programme.

If the latter explanation is correct it is of interest to compute a revised value for the mean particle diameter in the descending cloud on the assumption that the radiating lithium atoms are trapped within a cloud of lithium oxide smoke of density 2·1 gm. per cm.^{3}. Taking values for the remaining Stokes's parameters as before, the average particle size is now $\sim 7{\cdot}0\mu$; and if the ejection of the lithium atoms occurred initially at a height of ~ 160 km. the twilight phenomena might be expected to be present for about 90 days after the nuclear explosion. During this interval the 'lithium cloud' would have fallen from the upper to the lower limit of resonance emission.

From the evidence of the August, 1958, observations it appears that there was a five-day lag between the time of the nuclear detonation on August 1 and the first appearance of twilight lithium radiation. Thus the initial rate of fall must have been considerably higher than the steady descent of 0·4 km. per day observed afterwards, a probable value being ~ 10 km. per day if the upper limit of twilight emission is taken to be 110 km.

Taking all the above facts into consideration, it appears highly probable that the lithium airglow emission observed in October 1957, and again in August–September 1958, was man-made, and thus wholly unrelated to the passage of meteoritic dust through the Earth's upper atmosphere.

If indeed this is correct, the hypothesis of a meteoritic origin for both lithium and sodium atoms suggested by Barbier, Delannoy and Weill[3] is invalidated, leaving the important question of the terrestrial, or extra-terrestrial, origin of upper-atmosphere sodium still unanswered.

D. R. BARBER

Norman Lockyer Observatory,
University of Exeter, Salcombe Hill,
Sidmouth. Jan. 8.

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Magnetostriction and Palæomagnetism of Igneous Rocks

THE magnetization of dated igneous rocks has been much used for the study of the directions of the geomagnetic field in remote geological periods. This method is based on the supposition that igneous rocks become magnetized parallel to the field in which they cool. Its validity has been questioned on the grounds that the stress-histories of rocks may have a substantial influence on the directions of their remanent magnetic moments[1–3]. In particular it has been suggested that igneous rocks which cool under stress become magnetized in the direction of the prevailing field, but that when the stresses are released, substantial changes in direction may occur. Sills cooling under load and lava flows subject to cooling stresses present situations of the type envisaged: when specimens of such rocks reach the laboratory their original stresses have been relieved by erosion of overlying rock and the removal of the specimens from the ground.

Presumptive evidence for such magnetostrictive effects has been given by Graham, Buddington and Balsley[3], who subjected a number of metamorphic rocks to linear compressions of 250 kgm./cm.^{2} without heating and found reversible deflexions of up to 30° in the directions of magnetization. (It may be noted that no authors have used metamorphic rocks to draw conclusions about the directions of the Earth's magnetic field.) Stacey has pointed out[4] that, while the pronounced effect of isothermally applied axial compression is theoretically reasonable, it does not follow that thermo-remanent magnetization acquired under stress will show irreversible deflexions when the stress is removed. Field evidence[5] suggests the absence of large magnetostrictive effects.

A crucial laboratory experiment consists of subjecting igneous rock specimens to axial stress while they cool from high temperatures in a magnetic field, and then comparing the directions of the resulting magnetic moments after subsequent release of stress with that of the field. Accordingly, we have built a special non-magnetic press and heating system and made experiments on a number of igneous rocks from eastern Australia for which palæomagnetic data have been reported. Twenty cylindrical specimens covering a wide range of rock types, ages and geological environments, namely, Quaternary basalts, Mesozoic dolerite sills, Permian basalts, Devonian basalt and rhyolite flows, and Silurian porphyry of andesitic composition were placed in the press with their axes in the magnetic meridian. They were heated to 650° C. in a nitrogen atmosphere, held at that temperature for 15 min. and then allowed to cool over a period of several hours under an axial load of 500 kgm./cm.^{2}. The directions of magnetization of all the specimens were measured after their removal from the press. Errors of measurement and of alignment of specimens in the press were estimated by means of a duplicate set of specimens, which were given the same heat treatment, but without stress. The experiments were carried out in a non-magnetic hut where the geomagnetic dip I is 66° ± 1°. The results are summarized in Table 1, where $\bar{\theta}$ is the mean of the angles between the magnetic moments of the specimens and their axes, and δ is the standard deviation of the individual variations from the mean. Within the limits of the experiment, all the rocks, both stressed and unstressed, acquired moments in the direction of the field in which they cooled.

Table 1

	No. of specimens	I	$\bar{\theta}$	δ
Cooled under no load	20	66°	65·2°	2·5°
Cooled under 500 kgm./cm.^{2}	20	66°	65·4°	2·6°

This excellent agreement between the dip and the directions of artificial thermoremanent magnetization of the stressed and unstressed rocks indicates that large systematic errors due to magnetostriction are most improbable in igneous rocks of types normally used for palæomagnetic work.

P. M. Stott
F. D. Stacey

Department of Geophysics,
Australian National University,
Canberra, A.C.T.
Dec. 9.

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PHYSICS

'Whistler Mode' Echoes remote from the Conjugate Point

Echoes of very low frequency radio signals from station *NDT* on 17·44 kc./s. in Tokyo (25° N. geomagnetic latitude) with delays of about 0·2 sec. have been detected at Hobart, Tasmania (51° S. geomagnetic latitude). The Eckersley–Storey theory of 'whistler' propagation predicts that 'whistler mode' signals from Tokyo would return to the Earth's surface at a point (the geomagnetic conjugate point to Tokyo) near Darwin, Northern Territory, some 3,500 km. from Hobart.

The signals used were ⅛-sec. pulses sent every second for a 4-min. period. These transmissions were specially arranged by the Australian National Committee of the International Geophysical Year for a conjugate point experiment. The receiving equipment consisted of a single-turn, crossed-loop system, 70 ft. high, fed through a goniometer into a made-up receiver having four tuned radio-frequency stages and two tuned intermediate-frequency stages. The enclosed area of each loop was about 900 m.^{2}, the receiver intermediate frequency was 750 c./s. and the overall band-width was about 15 c./s. The signals were recorded on tape. The null direction of the crossed-loop system was adjusted so as to reduce considerably the direct signal since the *NDT* transmitter radiated a strong residual signal in between the pulses.

The direct signal from *NDT* was received with a strength of about 150 μV./m. during the day. All measurements were made at about 1250 local time. A series of distinct echoes were heard on only one of the five periods observed (1251½ E.A.S.T., September 30). On analysis these were found to have an average time delay of 0·21 sec. and a strength of 3 μV./m. Four direct pulses, each followed by an echo of about this delay, are shown in Fig. 1.

As only a few echoes were heard it was not possible to locate the source by direction-finding methods. It seems most likely from the delay times, however, that the echoes travelled via the 'whistler mode' from Tokyo to somewhere around Darwin and to Hobart via the Earth – ionosphere wave-guide mode. The observed 0·2-sec. delay is in agreement with observed whistler dispersions (from 30 to 50) for this geo-

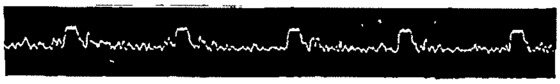

Fig. 1

magnetic latitude[1] and with a similar whistler mode echo experiment[2], using the station *NPM*, which is also on about this same geomagnetic latitude. The actual time spent in the whistler mode is found by adding the travel time for the direct pulse from Tokyo to Darwin (0·02 sec.). This time is then 0·23 sec.

Use can be made of these results to estimate the minimum electron density on the line of force originating from the transmitter. Whistler mode echoes of very low-frequency stations have an advantage over natural lightning flash whistlers in that the position of the transmitter is readily and accurately known. As borne out by this experiment, the assumption that short whistlers originate near one's conjugate point could lead to an error of more than thirty degrees of latitude.

The whistler mode delay time for a signal of frequency f travelling along a line of force in a medium of plasma frequency f_p and gyro frequency f_H is given by Storey's[3] equation (15) provided $f_H \gg f$ and $f_p^2 \gg f f_H$:

$$t = \frac{1}{2c}\int f_p\,(f f_H)^{-1/2}\,\mathrm{d}s$$

If we assume a dipole field and a constant electron density along the line of force (neglecting, for the moment, the effect of the lower ionosphere), we can get the approximate expression:

$$t \approx \frac{R_0}{c} f_{p_0}\,(f f_{H0})^{-1/2} \int_0^{x_g} (1-x^2)^{3/2}\,(1\ 3x^2)^{1/4}\,\mathrm{d}x$$

$$\approx \frac{R_0}{c} f_{p_0}\,(f f_{H0})^{-1/2}\, x_g(1-\tfrac{1}{4}x_g^2) + \text{terms in } x_g^5 \qquad (1)$$

where R is the distance from the Earth's centre (in units of the Earth's radius) and x is the sine of the geomagnetic latitude angle. The subscripts 0 and g refer to values in the geomagnetic equatorial plane and at the Earth's surface respectively. The maximum value of x is $x_g = \sin 25° = 0{\cdot}4$, so to within an accuracy of a few per cent we may neglect terms in x^4.

To this must be added a correction to take account of retardation through the lower ionosphere. Considering only the F region and assuming a parabolic layer of semi-thickness y_m, critical frequency f_{pc} and magnetic dip angle φ and assuming all other quantities to be constant within the integration limits, we find the correction to be applied is:

$$\Delta t = \tfrac{1}{4}\pi f_{pc}\,(f f_H)^{-1/2} y_m \operatorname{cosec}\varphi \qquad (2)$$

We can apply equations (1) and (2) to find f_{p_0} at R_0. On substitution of $x_g = \sin 25°$ and $t + \Delta t = 0{\cdot}23$ sec. we find $\Delta t = 0{\cdot}04$ sec. $R_0 = 1{\cdot}22$ radii and $f_{p_0} = 1{\cdot}75$ Mc./s. This suggests an electron density of about 20,000 cm.$^{-3}$ at a height of about 1,400 km.

We wish to thank Dr. G. R. Ellis, Upper Atmosphere Section, Commonwealth Scientific and Industrial Research Organization, for his useful suggestions.

R. L. DOWDEN
G. T. GOLDSTONE

Commonwealth Ionospheric Prediction Service,
Hobart, Tasmania.
Nov. 28.

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Multiple Geiger Counter Telescope Measurements of the Directions of Air Shower Particles

A MULTIPLE Geiger counter telescope was described recently by Shen and Singer[1], for which it was claimed that it responded preferentially to air showers the axis of which were parallel to the direction of the telescopes. Such an arrangement was tested by Layson, Malos and Millar[2] in a scintillator array with which total number of particles, situation of core and direction of shower axis were determined. The result of the latter investigation, namely, that the multiple Geiger counter telescope does not select in larger proportion air showers of preferred orientation, is supported by an unpublished experiment made by me in 1948 while at the School of Physics, University of Melbourne.

The arrangement used consisted of two Geiger counter telescopes, separated by 1 m., which could be tilted independently around an east–west axis. Each telescope consisted of two counters, 20 cm. long and of 3 cm. diameter, separated by 14 cm. A third counter could be introduced either in line or just outside the space joining the two outermost counters. The resolving time of 8 μsec. gives a rate of accidental counts of 10^{-3} per hr. for both the fourfold and sixfold coincidences, the main contribution being the accidental coincidences between the two telescopes.

The results of measurements made in a tent at an altitude of 1,750 m. are given in Table 1.

Table 1. SHOWER-RATE IN COUNTS PER HR. AT DIFFERENT ZENITH ANGLES

Zenith angle		Counters in each telescope		
Telescope 1	Telescope 2	2 counters	3 counters in line	3 counters centre out of line
0°	0°	1·96 ± 0·29*	1·56 ± 0·27	1·19 ± 0·24
30° N.	30° N.	1·50 ± 0·27	1·41 ± 0·24	0·98 ± 0·22
60° N.	60° N.	1·23 ± 0·22	0·66 ± 0·17	
90° N.	90° N.	1·25 ± 0·23	0·77 ± 0·16	0·94 ± 0·22
30° N.	30° S.		1·04 ± 0·22	
60° N.	60° S.		0·67 ± 0·17	

* The errors given are standard errors.

While the statistical accuracy is not sufficient to draw detailed conclusions, it is sufficient to show that such an arrangement of Geiger counters as was used does not respond selectively to showers incident within the opening angle of ± 12° of the telescopes. However, taking the three measurements at 60° and 90°, which give a mean of 0·70 ± 0·10, as general background due to showers arriving in all directions, we find that 0·87 ± 0·29, or about half the counts measured in the vertical position, are due to showers arriving from the zenith region. The excess of 0·71 ± 0·26 above background at 30° zenith angle gives an effective acceptance angle of ± 20–30° for that part of the rate which exceeds the background. The broadening can be explained both by the divergence of particle tracks in showers and by the fact that one particle only may frequently pass through two counters. The second effect is shown in the excess of the out-of-line measurements, the first in the excess of 0·37 ± 0·24 above background of the measurement at 30° N. 30° S., that is, with a divergence of the two telescopes of 60°.

As soon as it was evident that multiple telescopes were not sufficiently efficient in selecting showers incident in preferred directions the experiment was discontinued.

H. D. Rathgeber

F.B.S. Falkiner Nuclear Research and
Aldoph Basser Computing Laboratories,
School of Physics*,
University of Sydney.
Jan. 8.

* Also supported by the Nuclear Research Foundation within the University of Sydney.

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Permeability of Porous Media

Over the past decade much significance has been given to distribution of pore size characteristics in computing both saturated and unsaturated permeability of porous materials. Oil industry investigators[1] and soil scientists have adopted this approach to permeability computation with considerable success.

Childs and Collis-George[2] proposed a theory wherein flow is determined by the pore radii and by the probability of continuity of pores of different radii in adjacent planes. Marshall[3] greatly facilitated computation by using arbitrary equal volume components of the porosity.

Both these approaches show defects. The ratio of the observed and calculated permeability at saturation was used by Childs and Collis-George as a 'matching factor' to compute values for unsaturated permeability. If instead of the 'matching factor' (M), pore radii (not $1/h$) and the Poiseuille coefficient 1/8 are used, the computation yields the same result as the method of Marshall. Using the 1–½ mm. sand data of Childs and Collis-George, both the above methods give a calculated permeability at saturation of 76×10^{-8} cm.² against the experimentally determined value of 144×10^{-8} cm.². The form of the curve calculated by these methods for permeability against water-filled pore space does not fit the experimental findings. In the following paragraphs an alternative theory is proposed.

In a porous medium of porosity ε, the effective area available for flow may be defined with reference to the volume distribution of pore space thus:

$$\frac{\text{effective pore area}}{\text{pore volume}} = (n^2\pi r^2/n^3\pi r^3) \,.\, (k_1/k_2)$$

where there are n^3 pores or radius r in unit volume of the medium; k_1 and k_2 are characteristics of the shape of pore and for nearly spherical pores may be neglected in the subsequent derivation. From this relationship it can be shown that the effective pore area available for flow per unit area of section is $\varepsilon^{2/3}$. If there are m pore classes each occupying a volume component ε/m of the total porosity, then the effective flow area presented by each pore class is $\varepsilon^{2/3}/m$. However, flow is determined by the pore interaction or continuity between adjacent sections, so that permeability is determined by the sum of:

$$\begin{array}{l} a_1a_1r_1^2 + a_1a_2r_2^2 \ldots\ldots a_1a_mr_m^2 \\ \vdots \\ a_ma_1r_m^2 + a_ma_2r_m^2 \ldots\ldots a_ma_mr_m^2 \end{array}$$

where a_1, a_2, etc., are the pore areas devoted to pores of radius r_1, r_2, etc., in unit area of section.

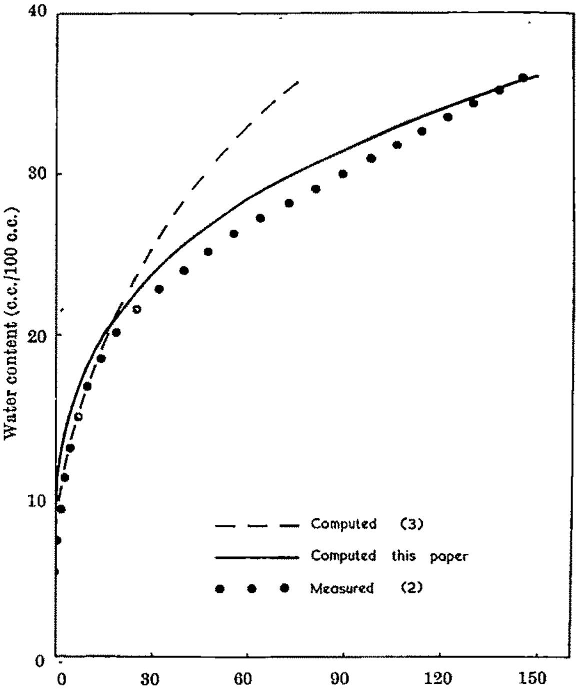

Fig. 1

Since there are m equal volume components of the porosity:

$$a_1a_1 = a_1a_2 = \ldots a_ma_m \text{ and}$$
$$a_1a_1 = \varepsilon^{2/3}/m \,.\, \varepsilon^{2/3}/m = \varepsilon^{4/3}/m^2;$$

when the Poiseuille coefficient is included the intrinsic permeability (K) is then given by:

$$K = \varepsilon^{4/3}m^{-2}\,[r_1^2 + 3r_2^2 \ldots\ldots (2m-1)\,r_m^2]/8 \quad (1)$$

The units of K are cm.² but for convenience in Figs. 1 and 2, K is expressed as μ^2.

For calculation of unsaturated permeability the value of ε adopted is that of the water-filled pore space and m remains constant. The r^2 series is commenced at the largest water-filled pore class. The basis for the variation of ε is due to changes in the water velocity which are not accounted for in the r^2 term of (1).

Figs. 1 and 2 enable a comparison to be made between the various methods for calculating permeability and the experimental results obtained by Childs and Collis-George for their 1 – ½ and ½ – ¼ mm. sands respectively. It can be seen from these figures that over a wide range of water content the curves calculated by the method herein proposed lie close to the experimental curves of permeability plotted against water content. The computed curves obtained either by the method of Childs and Collis-George (excluding M but including r and Poiseuille's 1/8) or by the method of Marshall are included for comparison; these latter curves clearly indicate that at high water contents the computed permeabilities are lower than those found experimentally.

Carman[4] has obtained the pore radius – volume curve for a Linde silica plug ($\varepsilon = 0{\cdot}506$); using these data and assuming an immobile monolayer the permeability of the plug has been calculated to be $2{\cdot}6 \times 10^{-15}$ cm.². This compares with the measured permeability[5] to CF_2Cl_2 at $-33{\cdot}1°$ C. of $3{\cdot}1 \times 10^{-15}$ cm.². It is interesting to note that the proposed

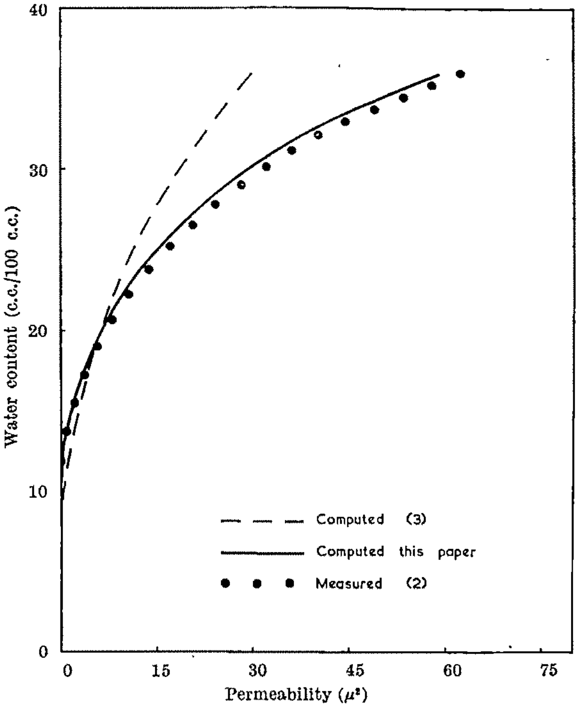

Fig. 2

equation for permeability calculation applies over a wide range of permeability, since the permeability of the Linde silica plug is almost 10^{-9} less than that for the 1 – ½ mm. sand.

A more extensive report of this work is being prepared for publication.

R. J. MILLINGTON
Department of Agronomy,
J. P. QUIRK
Department of Agricultural Chemistry,
Waite Agricultural Research Institute,
University of Adelaide.
Nov. 19.

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CHEMISTRY

Effect of Thermal Neutron Irradiation on Oxide Catalysts for the Decomposition of Nitrous Oxide

EFFECTS of radiation on catalysis have been investigated in various ways[1], including those of thermal neutron irradiation[2]. As thermal neutrons are of low energy, usually only a high flux density or a long exposure induces any change in catalytic activities. In this communication, however, we can report distinct effects on the catalytic activities of nickel oxide, aluminium oxide and stannic oxide used for the decomposition of nitrous oxide. The conditions were as follows: flux density, $10^{11}n$/cm.^{2}sec.; exposure time, 3 hr. With the aid of the (n, α) reaction of lithium-6 or boron-10 atoms, we may expect an intimate relationship between the catalytic activity and the lattice defects in the semi-conductor catalysts.

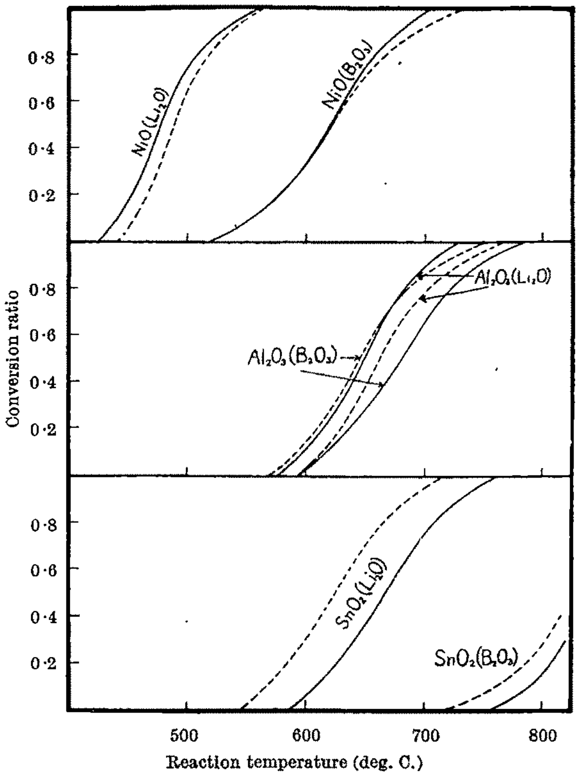

Fig. 1. Conversion ratio of nitrous oxide as a function of reaction temperature. The curves show the effect of thermal neutron irradiation on oxide catalysts. ——, Before irradiation; – – –, after irradiation

Separate samples of matrix powders of basic nickel carbonate, aluminium hydroxide and stannic hydroxide were dipped into aqueous solutions of lithium carbonate and boric acid, dried and fired at 750° C. for 2·5 hr. Lithium or boron atoms probably become distributed uniformly in matrices as oxides, the mixing ratio of atoms being 10 per cent, except for 1 per cent for lithium oxide in nickel oxide. The catalysts were irradiated in the *JRR*-1 nuclear reactor of the Japan Atomic Energy Research Institute at Tokaimura under the conditions mentioned above.

Table 1

Catalyst	NiO				Al_2O_3				SnO_2			
Addition Irradiation*	Li_2O bef.	 aft.	B_2O_3 bef.	 aft.	Li_2O bef.	 aft.	B_2O_3 bef.	 aft.	Li_2O bef.	 aft.	B_2O_3 bef.	 aft.
Frequency factor ratio	1·7	1	1·1	1	1·6	1	1	2·5	1	2·9	1	2·5
Apparent activation energy (kcal./mole)	22	23	19	19	23	23	23	24	21	20	43	30

* bef. and aft. refer to before and after irradiation, respectively.

The catalytic activity measurements were made one month later by a flow method. The conversion ratio as a function of the reaction temperature is shown in Fig. 1. Scarcely any induced radioactivity was detected : nickel oxide system, 0·2 mr./hr. (γ-rays) ; aluminium oxide system, none ; stannic oxide system, 0·4 mr./hr. (β-rays). On the assumption that the reaction is first-order, the apparent activation energy and the ratio of frequency factors before and after irradiation have been calculated and are shown in Table 1.

According to these results, the catalytic activity changes in every system : there is a small decrease with the nickel oxide system, an increase or decrease with the aluminium oxide system, and a remarkable increase with the stannic oxide system. Stannic oxide usually contains oxygen ion vacancies as an *n*-type semiconductor, and the number of these is readily increased by irradiation with alpha-particles which are produced by an (*n*, α) reaction with lithium-6 or boron-10 atoms. Nickel oxide contains excess oxygen ions as a *p*-type semiconductor and probably loses some of these on irradiation. The behaviour of the aluminium oxide system is probably due to its being an insulator.

The results of these experiments show that the larger the number of lattice defects, the more active is the semiconductor catalyst.

YASUKAZU SAITO
YUKIO YONEDA
SHOJI MAKISHIMA

Department of Applied Chemistry,
Faculty of Engineering,
University of Tokyo.
Oct. 9.

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A Simple Synthesis of Oxetanes

WE would like to report a simple method of synthesizing oxetanes. Oxetanes have generally been prepared by a multi-step procedure involving the basic elimination of a halide or acyl radical. The syntheses are involved, and yields are low to fair. Our methods consists of dissolving a diol in a mineral acid, introducing the mixture into a heated solution of base, and distilling off the cyclic ether produced.

Using this method, we have prepared oxetane, 1-methyl oxetane and 2,2-dimethyl oxetane. Indications are that this synthetic method is generally applicable to the preparation of cyclic ethers, including oxiranes. Further work using this method is in progress.

Preparation of 2,2-*dimethyl oxetane.* 2 moles of sulphuric acid (111 ml., 96 per cent) were added to 2 moles of neopentyl glycol (208 gm.) and the mixture was stirred. The resulting solution was very viscous. A solution of 240 gm. sodium hydroxide in 107 ml. of water was brought to the boiling point in a 1-l., 3-neck flask equipped with a stirrer, dropping funnel and distilling head. The glycol solution was then added from the dropping funnel at such a rate as to maintain boiling. About 30 min. was required for this addition. Some heating of the dropping funnel with a burner was required to keep the viscosity of the glycol solution low enough for an adequate rate of flow. 120 ml. of distillate was collected, which separated into two layers. The lower aqueous layer was separated and partially redistilled to recover the organic material. The organic layer from the partial redistillation was combined with the original organic layer and dried with calcium chloride. The dried organic layer was further dried with calcium hydride and distilled.

The product boiling between 79° and 83° C. amounted to 49·2 gm., or 29 per cent.

For further characterization, the product was again redistilled from calcium hydride. The fraction boiling between 79·2 and 80·3° C. (uncorrected) at a pressure of 756 mm. mercury was collected.

The density was found to be 0·8272 gm./ml. at 25° C. The refractive index, N_D(25·1° C.), was 1·3956.

An infra-red spectrum was obtained, and found to be identical to one previously published[1], except that there was no indication of either carbonyl or hydroxyl in our sample.

L. F. SCHMOYER
L. C. CASE

Department of Chemical and
Metallurgical Engineering,
Purdue University,
Lafayette, Indiana.
Oct. 14.

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Cis–trans Isomerism of Thioindigo Dyes in the Solid State

As the result of some preliminary observations by Stearns[1], an extensive study was made by Wyman and Brode[2] of the absorption spectra of solutions of several thioindigo dyes in benzene and chloroform under various conditions of illumination. Evidence was obtained that in solution thioindigo and its derivatives exist in equilibrium as two forms (*cis* and *trans*), which give rise to separate absorption bands in the visible region. X-ray diffraction studies on crystalline thioindigo by Madame von Eller[3] suggest, however, that in the solid state the dye is present in the *trans* form. It is thought that the electrostatic attraction between slight positive and negative charges on neighbouring sulphur and oxygen atoms, respectively, maintains the thioindigo molecule in the *trans* configuration and prevents isomerization[4]. Presumably in some cases these attractive forces will be weakened by solvents or by substitution in the thioindigo molecule.

Some observations have recently been made of the absorption spectra of several thioindigo compounds in the form of solid transparent films on quartz prepared by vacuum deposition. The results suggest that where substitution would not be expected to diminish the electrostatic charges on the sulphur and oxygen atoms the *trans* compound appears to be the stable form in the solid state ; but where reduction of these charges would be expected a mixture of *cis* and *trans* forms is found. Thus, as is seen in Fig. 1, solid films of thioindigo and 6 : 6′ dichlorothioindigo both exhibit a sharp absorption band in the visible region indicative of the sole presence of the *trans* isomer in the solid state. The presence of chlorine atoms in the 6 and 6′ positions in the thioindigo molecule should increase the negative character of the oxygen atom, and thus enhance the stability of the *trans* form. The introduction of methyl groups into the 4 and 4′ positions of this derivative of thio-

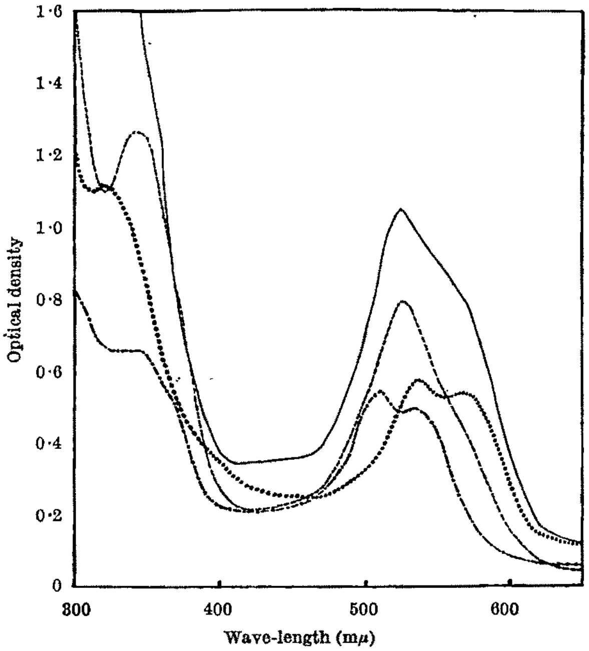

Fig. 1. The absorption spectra of solid films on quartz of thioindigo, ———; 6 : 6′ dichlorothioindigo, – – – – –; 4 : 4′ dimethyl 6 : 6′ dichlorothioindigo, –·–·–·–; and 5 : 5′ dichloro 7 : 7′ dimethylthioindigo, ·······

indigo will, however, tend to reduce the electrostatic charge on these atoms and as might therefore be anticipated 4 : 4′ dimethyl 6 : 6′ dichlorothioindigo exists in the solid state as a mixture of *cis* and *trans* forms. A similar result is found with 5 : 5′ dichloro 7 : 7′ dimethylthioindigo. The proportion of *cis* form appears to be substantially in excess with the unsymmetrical 4 : 4′ dimethyl 5 : 6′ : 7 trichlorothioindigo, which is not illustrated in Fig. 1. It is also interesting to compare the spectrum of 6 : 6′ diethoxythioindigo with the analogous chlorine derivative. The former compound containing the electron-donating ethoxy group appears to exist as a mixture of *cis* and *trans* forms in the solid state, whereas the presence of the electron-attracting chlorine atom in 6 : 6′ dichlorothioindigo favours the stabilization of the *trans* form. Comparison of the hemithioindigo dye, 1′ acenaphthene 2 thianaphthene indigo with thioindigo is also valuable. The *trans* form of the latter has two pairs of sulphur and oxygen atoms available for stabilization, whereas the former has only one. The hemithioindigo dye[5] exists in the solid state as a mixture in which the *trans* form predominates.

When the thioindigo dyes are applied to cellulosic materials from solution in an alkaline reducing agent the leuco dye absorbed on the cellulose is incapable of existing in *cis* and *trans* forms because of the single-bond character of the central carbon atom. On oxidation of the dyeing the central double bond is reformed and isomerization of the dye is possible. Measurements of the absorption spectra of such dyeings on transparent cellulose film (deplasticized) have been made. The spectra of dyeings of thioindigo and 6 : 6′ dichlorothioindigo indicate only the presence of the *trans* form, whereas other substituted derivatives appear to be present in the dyed material in both *cis* and *trans* forms. In some cases (for example, 1′ acenaphthene 2 thianaphthene indigo[5] and 4 : 4′ dimethyl 6 : 6′ dichlorothioindigo) it is possible to increase the proportion of the *trans* form in the dyed cellulose by giving the latter a swelling treatment (for example, boiling with dilute soap solution), but in other cases (for example, 5 : 5′ dichloro 7 : 7′ dimethyl thioindigo and 4 : 4′ dimethyl 5 : 6′ : 7 trichloro thioindigo) the *cis* form seems remarkably stable to treatments of this kind. In both cases, however, the tendency is for the absorption spectrum of the after-treated dyeing to be very similar to that of the solid film of the same dye prepared by vacuum deposition. It would seem that many of the thioindigo dyes are present in a fairly stable mixture of *cis* and *trans* forms under the conditions of their commercial utilization.

G. S. Egerton

Department of Textile Chemistry,
Faculty of Technology,
University of Manchester.
Dec. 23.

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Crystal Structure of β-Glycine

It has been reported that glycine has three polymorphic forms: (1) an ordinary form, α, the crystal structure of which was determined in 1939 by Albrecht and Corey[1], a precise analysis having recently been carried out by Marsh[2]; (2) an unstable form β, first described by Fischer[3]—Bernal[4] has reported preliminary results of X-ray investigations of unit cell dimensions and space group symmetry, but the results are not conclusive; (3) the third form γ, found by me[5] in 1954, the crystal structure of which has recently been determined[6]. In this connexion, it seemed worth while to investigate the crystal structure of the β-form so that a comparison might be made between these three crystalline forms, especially of their hydrogen-bond systems.

A brief account of the structural determination will be given: the cell dimensions and space group

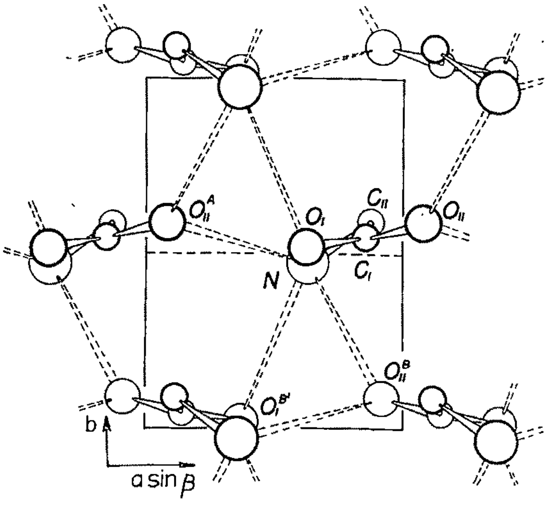

Fig. 1. A view of the β-glycine structure parallel to the *c*-axis, showing molecular layers connected by hydrogen bonds extending in the *b*-direction. Double dashed lines indicate hydrogen bonds

Table 1. COMPARISON OF THE CELL DIMENSIONS AND SPACE GROUPS OF α-, β- AND γ-GLYCINE

Form	Cell size (A.)					Space group	No. of molecules per cell	Molecular volume (A.³)
	a	b	c	β	Volume			
α*	$5{\cdot}102_0$	$11{\cdot}970_9$	$5{\cdot}457_5$	111° 42·3′	309·7	$P2_1/n$	4	77·4
β	$5{\cdot}077_4$	$6{\cdot}267_8$	$5{\cdot}379_9$	113° 12′	157·4	$P2_1$	2	78·7
γ†	7·037		5·483		235·1	$P3_1$ or $P3_2$	3	78·4

* See ref. 2. † See ref. 6.

are shown in Table 1 together with those of α- and γ-glycine.

Intensities were recorded using a single-crystal diffractometer[7]. A trial structure similar to that of α-glycine was adopted. Refinement of the structure was carried out using both (*h0l*) and (*0kl*) difference Fourier projections. The (*0kl*) difference map gave clear indication of the anisotropic thermal motions of the atoms along the *b*-axis. Taking into account these anisotropies, the structure was further refined. The resulting reliability factors were 0·06 and 0·05 for (*h0l*) and (*0kl*) reflexions, including contributions from hydrogen atoms.

The arrangement of the molecules of glycine in the β-form is indicated in Fig. 1, which shows that it consists of hydrogen-bonded molecular layers extending parallel to the (010) plane. These layers have the same configuration of molecules as the α-form.

It is of interest to compare the packing of these layers in the two types of glycine. These forms differ in the hydrogen-bond systems between layers. In β-glycine, those single layers connected geometrically by the two-fold screw axis are held together by hydrogen bonds extending in the *b*-direction. In α-glycine the nitrogen atom is buried within the double layer in such a way that very close contact of these two layers occurs.

The values for the bond-lengths and bond-angles of the molecule are very close to those found in the α-form. However, the departure of the nitrogen atom from the plane containing the carboxyl group by 0·59 A. is somewhat larger. In Table 2 the bond-lengths and bond-angles are given together with N..O interatomic distances and C—N..O angles between neighbouring molecules.

Table 2. BOND-LENGTHS AND BOND-ANGLES IN β-GLYCINE

Length (A.)	Angle (deg.)	Length (A.)	Angle (deg.)
N—C_{II} 1·48	C_I—C_{II}—N 111	N..O_I^C 2·76	C_{II}—N..O_I^C 113
C_I—C_{II} 1·52	O_I—C_I—C_{II} 118	N..O_{II}^A 2·82	C_{II}—N..O_{II}^A 115
C_I—O_I 1·24	O_{II}—C_I—C_{II} 116	N..$O_I^{B'}$ 3·00	C_{II}—N..$O_I^{B'}$ 145
C_I—O_{II} 1·25	O_I—C_I—O_{II} 126	N..O_{II}^B 3·01	C_{II}—N..O_{II}^B 83

A more detailed account of this work will be published elsewhere.

YŌICHI IITAKA

Mineralogical Institute,
Science Department,
University of Tokyo,
Hongo, Tokyo.

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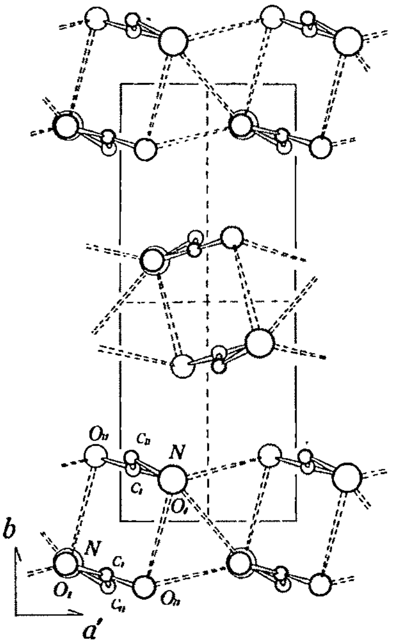

Fig. 2. A view of the α-glycine structure parallel to the *c*-axis, showing molecular double layers held together by hydrogen bonds (after G. Albrecht and R. B. Corey, ref. 1)

Circular Gas Chromatograph

IT is reasonable that a gas chromatographic apparatus can be arranged in a circular form. Fig. 1 shows a chromatographic column connected head to tail. In operation, the carrier gas is brought to a desired initial pressure using the stopcock arrangement that is also utilized for sampling. The pump in the circuit is used to circulate the carrier gas previously introduced. Simple laboratory peristaltic-type pumps have been found satisfactory for circulating the gas stream. A bleed stream of carrier gas from a separate source is used in the reference side of a resistance-wire thermal-conductivity detector. The columns are packed with crushed insulating brick of conventional size. Temperature control is accomplished by either liquid or air baths.

The stationary liquid phase normally used in gas chromatography has a low volatility relative to the compounds being separated. With the circular apparatus, the liquid need not have a low volatility. Fig. 2 shows the record for separation at room temperature of acetone, boiling point 56·2° C., and normal hexane, boiling point 68·7° C., using methanol, boiling point 64·7° C., as the liquid phase. Acetone travels more slowly than hexane due to selective adsorption and is separated after passage through half the circular column. During the time required for acetone to make an additional circuit of the column, the hexane has gone through the detector two additional times.

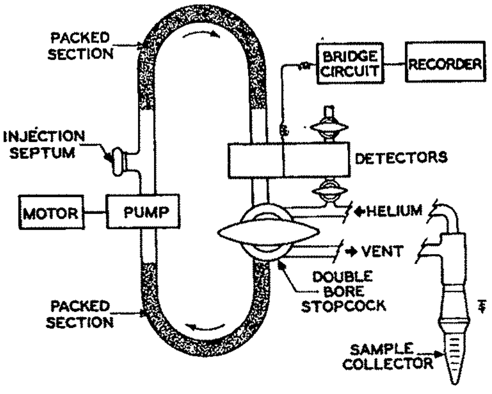

Fig. 1. Schematic diagram of circular gas chromatograph

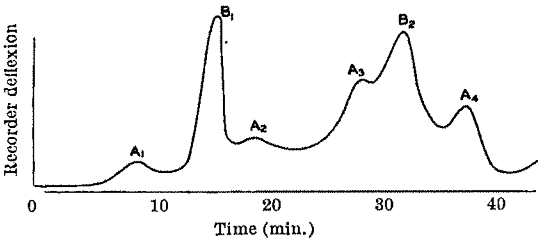

Fig. 2. Injection of a mixture of *A*, *n*-hexane, and *B*, acetone, using a methanol column

In a separate experiment, the retention time of normal heptane is 4·5 min. for the solid support coated with methanol and 0·5 min. for the support with no liquid present under the same conditions. Therefore, the methanol clearly is acting as a partitioning liquid.

There are several advantages in being able to use volatile partitioning liquids. A wider range of liquids can be utilized. In addition, non-analytical chromatographic applications are often of more interest if there is less difference in the boiling points of the liquid phase and the partitioned components. Experimentally, volatile partitioning liquids can be added through the sample injection septum and allowed to become distributed uniformly *in situ*.

The dead volume in the detector cell and mixing action of the pump cause a loss in efficiency as compared to a single pass through a comparable straight column. Column efficiency is evaluated by conventional theoretical plate calculations. However, using 2,4-dimethylsulpholane as the liquid phase in a circular 10-ft. column, the efficiency was found to increase linearly with the number of cycles up to a length of column equivalent to 150 ft. This arrangement, therefore, offers a way to operate the equivalent of a long column at a low and more efficient ratio of the initial pressure to that at the outlet.

On a preparatory scale, use of the circular arrangement conserves solid support, liquid phase, carrier gas, and the energy required for thermostatic control. The optimum length of column for separation can be selected by choosing the proper number of cycles the materials are circulated. The equipment can be made automatic.

Roger S. Porter
Julian F. Johnson

California Research Corporation,
Richmond, California.
Oct. 17.

BIOCHEMISTRY, PHYSIOLOGY and MEDICAL SCIENCES

Starch Gel Electrophoresis Studies on Abnormal Proteins in Myeloma and Macroglobulinæmia

We have investigated by starch gel electrophoresis[1], using a technique described in a previous paper[2], 28 sera from patients with multiple myeloma, 13 from patients with macroglobulinæmia, 4 sera from cases with atypical dysproteinæmia. In every case a characterization of abnormal serum components was carried out previously, using free-boundary electrophoresis[3], analytical ultracentrifuging[4], agar gel and immuno-electrophoresis[5].

Concerning plasmocytoma, in so-called 'γ-myeloma' (according to free-boundary electrophoresis at *p*H 8·6, ionic strength 0·1 in veronal buffer), the sera demonstrated in starch gel either a high 'fast' or a high 'slow-γ' component. On sedimentation diagrams, a 6 *S* component was seen in most cases.

In cases of 'β-myeloma' in starch gel, abnormal components, as shown by quantitative results, are located in various positions, but in the α-β and slow-α 2 zone.

In a typical β-myeloma, starch gel electrophoresis shows three abnormal components (as compared with normal serum). The euglobulinic fraction of the serum similarly shows three components. In one case of α-myeloma the abnormal component is in the post-albumin zone.

Concerning macroglobulinæmia, sera with high levels of heavy components (mainly 17 *S*), ascertained as β-2 *M* globulins by immuno-electrophoresis, yield, in starch gel, no characteristic patterns. That may be due (Silbermann, H. J., personal communication) to the non-displacement of macroglobulins in the gel.

Four cases of 'dysproteinæmia were selected from 136 patients with 'myeloma-like' patterns. These cases are characterized by the absence of bone marrow plasmocytosis, negativity of X-ray investigations, but β-2 *M* globulins and/or heavy components (by sedimentation) were lacking. Electrophoretic pattern in starch gel resembles that of myeloma.

The influence of size of molecule may be emphasized in the case of β-lipoprotein in starch gel[6].

In the present study some findings seem to be related to the same phenomenon; for example, an abnormal α-component (mobility 4 cm.^{2}/volt/sec. 10^{-5} at *p*H 8·6) shows in starch gel an increase in the post-albumin zone, and 92 per cent of the serum components migrated as light components by ultracentrifugating the (4 *S*) component.

In conclusion, we feel that investigation of dysproteinæmias using electrophoresis in starch gel may be a very promising subject.

J. M. Fine

Centre national de transfusion sanguine, Paris.

R. Creyssel

Laboratoire d'hématologie,
Institut Pasteur de Lyon.

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The Iron-Protein Link in Hæmoglobin and Myoglobin

It is generally considered that the hæm iron in hæmoglobin and myoglobin and their derivatives is bound to the apoprotein through histidine imidazole groups, although there is some uncertainty[1] whether the stronger of the two postulated imidazoles (ascribed $pK_1 = 5 \cdot 3$ in ferrihæmoglobin and ferrimyoglobin[2]) has been so identified.

The *p*H stability curves of native and recombined horse ferrimyoglobin are shown in Fig. 1, obtained after addition of solutions of the native protein and of the components of the recombined protein to a series of phthalate and phosphate buffers (*p*H 2·3–7·0, $\mu = 0 \cdot 05$, $T = 21°$ C.). The solutions were stood for 16 hr. at 1° and then 2 hr. at 21° before reading the absorbances at 408·5 mμ, the Soret *p*H 7·0 peak. Curves of similar type and approximate position were obtained for ferrihæmoglobin, measured at 405 mμ. When hæmatin or ætiohæmatin combines with native globin or apomyoglobin at *p*H 6–7, a comparable major increase in Soret peak absorbance occurs[3] between *p*H 4 and 6 (Fig. 1). The curves therefore appear to indicate dissociation of the hæmatin iron from specific groups in the apoprotein.

A reversible equilibrium between 'acid hæmatin' and ferrihæmoglobin exists[4] within the *p*H range 3·0–6·0, and while the curves of Fig. 1 and similar ones obtained by removal of hæmatin with acetone[5] do not exactly fit dissociation curves of acids with single equilibrium constants, they could represent such curves partly masked by overlapping contributions from other linkages, such as hæmatin propionyl – apoprotein or iron – anion ligand.

Since at *p*H 5·3 only a very small decrease in Soret peak absorbance occurs and only a very small fraction of the hæmatin is extracted by acetone[5], the specific groups indicated, which I consider to be those binding the hæmatin iron to the apoprotein, are unlikely to be the postulated imidazoles of $pK_1 = 5 \cdot 3$. A *pK* of this value could be related to dissociation of hæmatin propionyl. Rather it would appear that groups of the nature of aspartyl β- or glutamyl γ-carboxyls ($pK \approx 4 \cdot 7$) are ionizing. Potentiometric titration studies of horse carboxyhæmoglobin[6] have also suggested carboxyl groups (of *pK* approximately this value) linked to the hæm, while iron–carboxyl linkages have been considered to occur in recombined hæmoglobin[1] and, on evidence from both spectrophotometric and enzymatic activity studies, in the related hæmoprotein, horse-radish peroxidase[7].

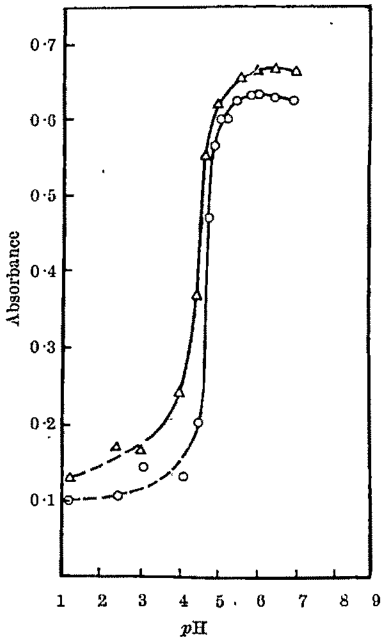

Fig. 1. *p*H stability curves of native and recombined horse ferrimyoglobin in the *p*H range 1–7 from the absorbances at 408·5 mμ. Native ferrimyoglobin (—○—○—), 0·1 ml. $9 \cdot 3 \times 10^{-5}$ *M* solution + 10 ml. buffer; recombined ferrimyoglobin (—△—△—), 0·05 ml. $1 \cdot 8 \times 10^{-4}$ *M* protohæmatin in 0·01 *M* sodium hydroxide + 0·10 ml. $2 \cdot 1 \times 10^{-4}$ *M* apomyoglobin solution + 10 ml. buffer. Buffers: *p*H 1·2, hydrochloric acid; 2·3–6·2, phthalate; 6·5–7·0 phosphate; $\mu = 0 \cdot 05$. Temperature of measurement, 21° C. Path-length, 4 cm.

J. E. O'Hagan

Red Cross Blood Transfusion Service,
Brisbane,
Queensland.

Dec. 12.

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Chromatographic Behaviour of Human Albumin labelled with Iodine-131

The *in vivo* behaviour of plasma proteins labelled with iodine-131 prepared by methods developed in this laboratory[1,2] is almost identical with that of the corresponding proteins labelled with carbon-14 by the biosynthetic procedure[3,4]. Human albumin preparations iodinated by these methods have a chromatographic distribution similar to that of unlabelled albumin when analysed on anion exchange columns of diethylaminoethyl cellulose (Fig. 1). Similar results have been obtained on cation exchange columns of carboxymethyl cellulose. On the other hand, commercially iodinated human albumin (Abbotts, Chicago), which has been extensively used in clinical studies of albumin turnover, has recently been shown to have a chromatographic distribution markedly different from native albumin[5]. It is now recognized that preparations of protein labelled with iodine-131 may be adversely affected by a variety of factors, including the method of fractionation, the technique of iodination[1], preliminary heat treatment of the protein[6] and self-irradiation[7]. Investigation of these variables has shown that by far the greatest changes in chromatographic behaviour of albumin labelled with iodine-131 result from self-irradiation.

Human albumin prepared by ion exchange chromatography[8] was iodinated at a mean ratio of less than 1 atom per molecule using the iodine monochloride method recently described by McFarlane[2]. The effect of self-irradiation was investigated in solutions containing 2–3 mgm. albumin and 500–700 μc. of iodine-131 per ml. Solutions were stored at 3° C. and tracer amounts added to human serum at intervals after labelling. Irradiation-levels between 40 and 85 k.rads produced a progressive displacement of the radioactive from the native albumin (Fig. 2). The electrophoretic mobility on paper of these irradi-

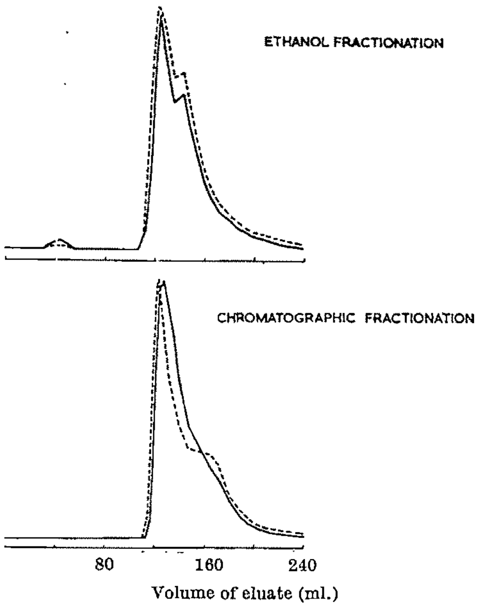

Fig. 1. Chromatographic analysis of human albumin prepared by ethanol fractionation and ion exchange chromatography. Iodinated albumin (0·5 mgm.) was added to 50 mgm. of the corresponding unlabelled albumin before dialysis. The analysis was performed on diethylaminoethyl cellulose columns using a gradient elution with phosphate buffer *p*H 7·1, 0·005 *M* and 0·30 *M* sodium dihydrogen phosphate. Protein distribution is indicated by solid lines and radioactivity by broken lines

ated proteins remained unchanged although as previously shown[7] albumin 'tailing' was increased by irradiation at doses above 45 k.rads.

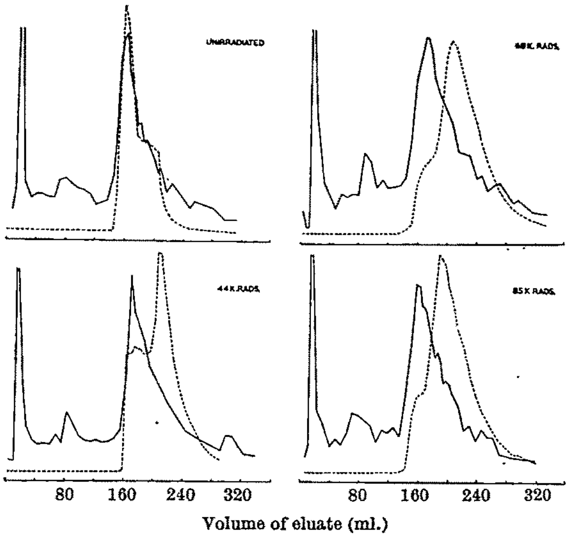

Fig. 2. Effect of irradiation on the chromatographic behaviour of human albumin labelled with iodine-131 and prepared by chromatography. Tracer amounts of the labelled solution which contained 650 μc. iodine-131 per ml. and 2·5 mgm. albumin per ml. were added to normal human serum immediately after iodination and after storage for 7, 14 and 22 days, which provided self-irradiation doses of 44 k.rads., 68 k.rads, and 85 k.rads respectively. Chromatography was carried out as in Fig. 1. Protein distribution is indicated by solid lines and radioactivity by broken lines

In contrast to the marked effect of irradiation only minor differences in chromatographic behaviour were induced by altering the methods of albumin fractionation and iodination. Human albumins prepared by zone electrophoresis, ion exchange chromatography, ethanol fractionation[9] and crystallization from concentrated salt solution (Behringwerke, Marburg-Lahn) were examined. After iodination[2] these proteins were added to the corresponding unlabelled albumin so that labelled molecules constituted not more than 1 per cent of the protein analysed. The various albumin preparations were not chromatographically identical, but in all of them the distribution of labelled and unlabelled molecules was similar. Results obtained with two of these preparations are shown in Fig. 1. Albumin iodinated using hypochlorite[10] showed a second minor peak of radioactivity displaced beyond the native albumin. Preliminary heat treatment of human albumin in the presence of stabilizers did not alter the chromatographic pattern.

It is concluded that human albumin can be prepared and iodinated without gross alteration of its behaviour on the ion exchange columns used in this investigation. Similar results have been obtained with rat and rabbit albumins. The chromatographic dissociation of native human albumin and that labelled with iodine-131 recently reported[6] can be reproduced in dilute protein solutions by self-irradiation at levels above 40 k.rads. Chromatographic analysis appears to be the most sensitive physicochemical method available for detecting undesirable alterations in samples of albumin labelled with iodine-131 for metabolic studies.

I am grateful for helpful discussions with Dr. A. S. McFarlane and Dr. R. R. Porter. Dr. P. S. Charlwood and Prof. H. E. Schultze kindly supplied samples of human albumin.

S. COHEN

National Institute for Medical Research,
Mill Hill, London, N.W.7.
Nov. 25.

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1,6-Di-(2-Bromoethylamino)-1,6-Dideoxy-D-Mannitol Dihydrobromide: a New Cytostatic Agent

RECENTLY it was reported that 1,6-di-(2-chloroethylamino)-1,6-dideoxy-D-mannitol dihydrochloride[1] shows significant tumour inhibitory effect[2]. This compound ('Degranol', 'Mannomustine') has been employed in the treatment of malignant hæmatological diseases[3].

Since the chlorine atoms of this compound show comparatively slight reactivity, and since the cytostatic effect in the group of mustard nitrogen derivatives increases in general parallel to the reactivity of halogen atoms of the 2-halogenethylamino group[4], in further experiments we replaced the chlorine atoms of 1,6-di-(2-chloroethylamino)-1,6-dideoxy-D-mannitol dihydrochloride with the more active bromine atoms. The synthesis of this bromine derivative (1,6-di-(2-bromoethylamino)-1,6-dideoxy-D-mannitol dihydrobromide) was performed by analogy with the (1,6-di-(2-chloroethylamino)-1,6-dideoxy-D-mannitol dihydrochloride from the 1,6-diethylenimino-1,6-dideoxy-3,4-*iso*propylidene-D-mannitol with concentrated aqueous hydrobromic acid. The former compound crystallizes from *iso*propanol, or aqueous dioxan in colourless needles which are easily soluble in water: m.p. 204–205° C. while decomposing; $[\alpha]_D^{20} = + 10\cdot6°$, water, $c = 1\cdot0$. (Found: C 21·4, H 4·6, Br 57·4. $C_{10}H_{24}O_4N_2Br_4$ requires C 21·6, H 4·4, Br 57·5.)

As animal experiments presented in the next communication prove, 1,6-di-(2-bromoethylamino)-1,6-dideoxy-D-mannitol dihydrobromide is active as expected in much smaller dose than the chlorine derivative and its therapeutic effectiveness is more favourable.

L. Vargha
T. Horváth

Research Institute of Pharmaceutical Industry,
Budapest VII, Hungary.

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Effect of 1,6-Di-(2-Bromoethylamino)-1,6-Dideoxy-D-Mannitol Dihydrobromide on Tumours of Laboratory Animals

The chemotherapeutic effect of the new compound 1,6-di-(2-bromoethylamino)-1,6-dideoxy-D-mannitol dihydrobromide (see preceding communication) has been tested on different tumours of laboratory animals (Table 1). The compound was administered once daily in succession intraperitoneally after the appearance of palpable inoculated tumours. In comparison we tested the effect of the chlorine derivative ('Degranol', 'Mannomustine')[1] in the treatment of the same tumours.

From the results it is obvious that the 1,6-di-(2-bromoethylamino)-1,6-dideoxy-D-mannitol dihydrobromide inhibits the growth of rat and mouse tumours to a greater extent than 'Degranol' (Fig. 1).

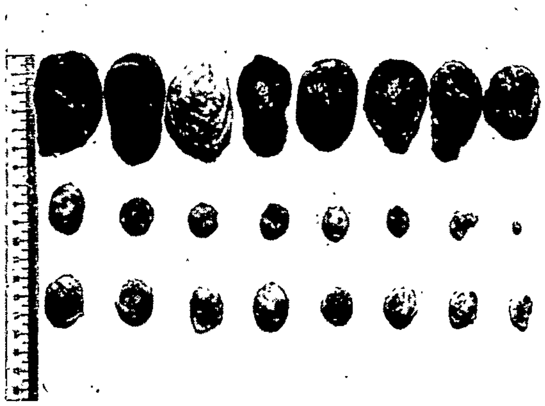

Fig. 1. Inhibition of the growth of the subcutaneous form of Yoshida sarcoma by 1,6-di-(2-bromoethylamino)-1,6-dideoxy-D-mannitol dihydrobromide (DBM) (*R*/13) and the chloride derivative (BCM)

Top, control; middle, DBM; bottom, BCM

Table 1. Degree of Inhibition of the Growth of Rat and Mouse Tumours by 1,6-Di-(2-bromoethylamino)-1,6-dideoxy-D-mannitol Dihydrobromide (DBM) (*R* 13) and the Chloride Derivative (BCM) ('Degranol')

Tumours tested	Degree of inhibition (per cent) DBM (*R* 13)	BCM ('Degranol')
Guérin rat carcinoma	89	
Guérin rat carcinoma	64	54
Yoshida rat sarcoma subcutaneous form	93	84
Ehrlich mouse carcinoma	39	21
S_{37} mouse sarcoma	53	29
Amytal mouse ascites (ref. 2) sarcoma	44	19

For the treatment of mice with tumours, 3–5 mgm./kgm. daily dose is necessary, and for the treatment of tumour-bearing rats 2–3 mgm./kgm. is sufficient. In contrast, the daily therapeutic dose of 'Degranol' corresponds to 20 mgm./kgm. for mice and 15 mgm./kgm. for rats.

When given 34 times in daily succession, the therapeutic dose to rats, in the bone marrow a slight decrease of leucopoietic elements is to be observed. Study of the blood reveals moderate leucopænia with more marked lymphopænia. Microscopically, in the spleen and lymph nodes atrophy of the follicles can be found.

J. Baló
G. Kendrey
J. Juhász
I. Besznyák

I. Department of Pathological Anatomy and
Experimental Cancer Research,
Medical University,
Budapest VIII,
Hungary.

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Biochemical Heterogeneity of the Ribonucleic Acid synthesized by *Escherichia coli B* after Irradiation with Ultra-violet Light

It is well known that the effects of radiation on the biosynthesis of ribonucleic acid and protein are reduced slightly under conditions in which the synthesis of deoxyribonucleic acid is inhibited almost completely[1]. There have been few investigations of the ribonucleic acid synthesized after irradiation.

It has recently been suggested by Haas and Doudney[2,3], however, that mutation of *Escherichia coli* is induced by ultra-violet light through the incorporation of modified nucleic acid precursors into the ribonucleic acid, resulting in modifications of the latter. It is thus of interest to investigate whether any chemical or biochemical modifications occur in ribonucleic acid synthesized after irradiation.

An overnight culture of *E. coli B*(*H*) was inoculated in *tris*–glucose medium and harvested by centrifugation when growth was in the logarithmic phase. The cells collected were washed once with physiological saline and resuspended in the same saline. Half the suspension was irradiated with ultra-violet light. Irradiation was carried out by germicidal lamp ('Toshiba' *GL*-1502, 15 W.) for 60 sec. at a distance of 30 cm. The other half was used, unirradiated, as control. Both irradiated and control cells were collected and resuspended in *tris*–glucose medium

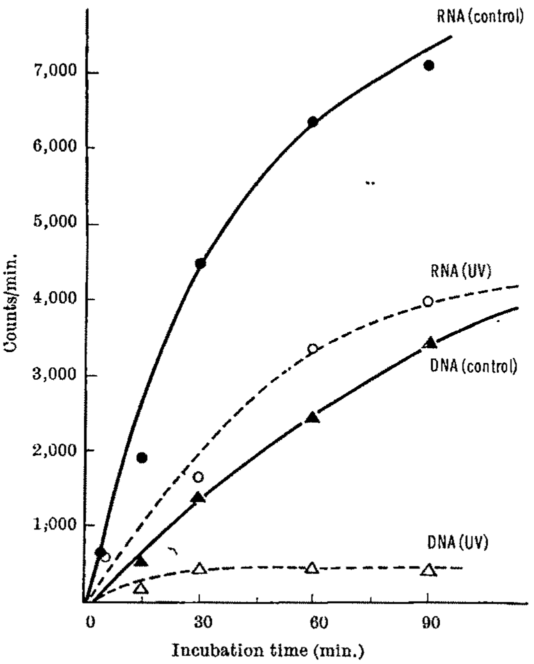

Fig. 1. The incorporation of phosphorus-32 into the ribonucleic acid and deoxyribonucleic acid fractions of *Escherichia coli B*(*H*), with and without irradiation with ultra-violet

containing phosphorus-32 and incubated at 37° C. From time to time samples were withdrawn and the phosphorus-32 incorporated was fractionated by the procedure of Schmidt and Thannhauser. The incorporation of phosphorus-32 into the ribonucleic acid and deoxyribonucleic acid fractions after irradiation with ultra-violet is shown in Fig. 1. The survivals were about 10^{-5}, and the total amount of phosphorus-32 incorporated into the ribonucleic acid fraction was about 50 per cent after 60 min. as compared to the control. Inhibition of incorporation of phosphorus-32 into the deoxyribonucleic acid fraction was nearly complete.

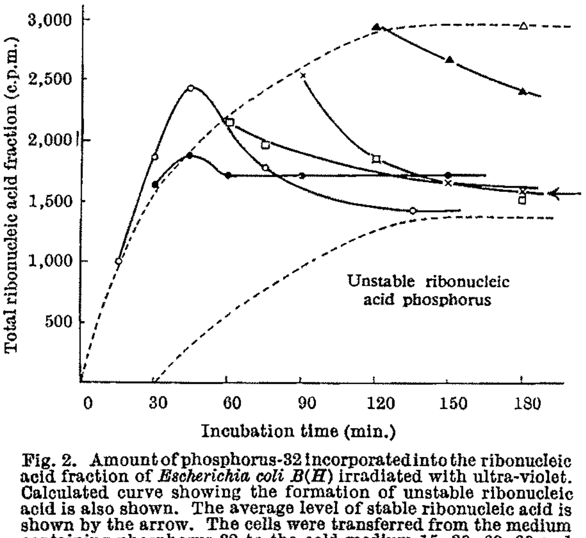

Fig. 2. Amount of phosphorus-32 incorporated into the ribonucleic acid fraction of *Escherichia coli B*(*H*) irradiated with ultra-violet. Calculated curve showing the formation of unstable ribonucleic acid is also shown. The average level of stable ribonucleic acid is shown by the arrow. The cells were transferred from the medium containing phosphorus-32 to the cold medium 15, 30, 60, 90 and 120 min. after the post-irradiation incubation; curves on symbols: ○, ●, □, ×, ▲ show the fate of phosphorus-32 incorporated into ribonucleic acid fractions during these periods respectively

Fig. 2 shows the phosphorus-32 incorporated in the ribonucleic acid fraction after the cells were removed from the medium containing phosphorus-32 at various times, washed, and reincubated in *tris*–glucose medium which contained no phosphorus-32.

Part of the phosphorus-32 incorporated into the ribonucleic acid fraction for incubation periods longer than about 30 min. has a tendency to be released from that fraction during re-incubation. But as shown in Fig. 2, the final level of phosphorus-32 in ribonucleic acid remains nearly constant regardless of the time when the cells are transferred to the isotope-free medium. When incubation with phosphorus-32 is shorter than 30 min., the amount incorporated reaches the final level described above and is conserved thereafter.

Ribonucleic acid phosphorus was conserved in unirradiated control cells as reported previously[4].

These results suggest that although the incorporation of phosphorus-32 into the ribonucleic acid fraction may occur in *E. coli* after irradiation with ultra-violet light, the fraction is composed of two parts, one stable and the other unstable. In addition, the incorporation into the unstable fraction seems to occur after a time-lag of 30 min. following irradiation (calculated curve is shown in Fig. 2). Since such a loss of phosphorus-32 from the ribonucleic acid fraction was not observed when the cells were incubated in the medium containing phosphorus-32 for 3 hr. after irradiation, and since the incorporation of phosphorus-32 was observed even when the isotope was added after incubation for 2 hr., the phosphorus in the unstable ribonucleic acid fraction seemed to be characterized by its continuous replacement.

The formation of unstable ribonucleic acid has been reported in some cases[5,6] and the degradation of these ribonucleic acids was found to be restored by the addition of chloramphenicol. The effects of the addition of chloramphenicol (40 μgm. per ml.) and dinitrophenol (10^{-3} *M*) and that of the omission of glucose from the medium were tested in our system but none of these agents was observed to have any effect on the loss of ribonucleic acid phosphorus.

The chemical difference between normal ribonucleic acid and that synthesized after irradiation with ultra-violet light is now under investigation, and a detailed report will be published elsewhere.

We wish to thank Mr. M. Izawa, chief of the Chemistry Division of the National Institute of Radiological Sciences, for his encouragement, and Prof. I. Watanabe and his colleagues of the Department of Biochemistry in the University of Tokyo for their gift of the bacterial strain and helpful discussions.

KENSHI SUZUKI
JŌJI ONO

National Institute of Radiological Sciences,
Chemistry Division,
2–2 Kasumigaseki,
Chiyoda-ku,
Tokyo.

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Activation of Amino-Acids in Relation to the Synthesis of Silk Proteins

THE 'activation' of the carboxyl groups in amino-acids is often assumed to be an indispensable preliminary stage in the biosynthesis of protein. The rate of the activation is known to vary with various amino-acids. The question arises whether there is any relation between the rate of activation of an amino-acid and its content in the protein. The silk-glands of the silkworm lend themselves particularly well to the study of such a problem since they produce two well-defined proteins, the amino-acid composition of which is known. While the posterior silk-gland produces 'fibroin', which contains 42 per cent of glycine and 28 per cent of alanine, the middle silk-gland produces 'sericin' containing 30 per cent of serine[1]. We have studied the activation of a number of amino-acids present in these two proteins of the silkworm caterpillars (*Bombyx mori* L.). The '*p*H 5 enzymes' were obtained from the posterior and middle silk-glands as well as from the hæmolymph. The hydroxamic method was used to determine the rate of the activation of the carboxyl groups in the amino-acids. The composition of the enzymatic mixture was approximately the same as that referred to by Davie, Koningsberger and Lipmann[2]. The results which we obtained are given in Table 1.

Table 1. THE RATE OF THE AMINO-ACID ACTIVATION IN SILK-GLANDS AND IN THE HÆMOLYMPH OF SILKWORM CATERPILLARS. THE RESULTS ARE EXPRESSED AS MEANS WITH THE STANDARD DEVIATION OF THE MEAN

Amino-acids	μmole of hydroxamates/1 mgm. of protein/hr.		
	Posterior silk gland	Middle silk gland	Hæmolymph
Alanine	0·068 ± 0·03	0·088 ± 0·03	0·085 ± 0·04
Glycine	0·038 ± 0·00	0·073 ± 0·01	0·057 ± 0·02
Glutamic acid	0·031 ± 0·02	0·258 ± 0·07	0·105 ± 0·03
Histidine	0·098 ± 0·01	0·286 ± 0·15	0·060 ± 0·02
Serine	0·318 ± 0·05	0·168 ± 0·04	0·079 ± 0·02
Tryptophan	0·623 ± 0·10	0·406 ± 0·21	0·071 ± 0·03
Tyrosine	0·600 ± 0·19	0·370 ± 0·18	0·150 ± 0·06

The two amino-acids which showed the highest rate of activation were tryptophan and tyrosine. Yet it is known that there are only traces of tryptophan in the proteins of the silk. Glycine, on the other hand, showed the lowest rate of activation in spite of its high concentration in the silk proteins. Thus no relationship could be established between the rate of the activation of amino-acids as measured by the hydroxamic method and their actual concentration in the proteins. We then decided to investigate the possibility that the activation of glycine proceeds mainly through transacylation. In view of the high rate of activation of tryptophan and tyrosine it seemed that the active forms of these two amino-acids might participate in such a process. An attempt was therefore made to observe activation of glycine in the presence of either tryptophan or tyrosine. Chromatographic analysis of the mixtures, however, did not reveal the presence of any hydroxamic acids other than those of tryptophan or tyrosine. As regards the possibility that glycine activation occurs outside the silk-glands, we found that in the hæmolymph the activation is negligible. Thus the question as to how glycine is introduced in the course of silk protein synthesis still remains open. Our results, however, suggest that the incorporation of amino-acids into protein must occur by means other than the activation of the carboxyl groups.

A detailed report of this work will be published in the *Acta Biochimica Polonica*.

J. HELLER
P. SZAFRAŃSKI
E. SUŁKOWSKI
Institute of Biochemistry and Biophysics,
Polish Academy of Sciences,
Warsaw. Nov. 24.

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Casease in *Entamoeba histolytica*

CASEASE, the proteolytic, casein-hydrolysing enzyme, has been reported in many bacteria. It has not hitherto been detected in the protozoan, *Entamoeba histolytica*. In earlier studies, Nakamura[1] reported the absence of casease in certain strains of the amœbæ. It was thought that the failure to demonstrate the enzyme might have been due to the comparatively large amounts of casein in the assay plates. Therefore, the experiments were repeated using a modification of the same method but incorporating smaller concentrations of casein in the test plates.

The amœbæ were cultured in coagulated whole egg slants overlaid with Ringer–liver extract solutions. Cultures 72 hr. old were pooled and washed four times in saline solution. The supernatant from the final washing was also tested for enzymatic activity; any remaining associated bacteria from the amœba stock cultures would be contained in this supernatant. In addition, the associated bacteria were assayed for casease activity in the absence of the amœbæ.

The method consisted of placing large drops of material to be assayed on the surface of 1·0 per cent agar plates containing 0·2 per cent casein, incubating for 12 hr. at 20–25° C., and flooding the agar plates with a mercuric chloride–hydrochloric acid solution (a protein-precipitating agent). Clear areas in the opaque casein-agar plates indicated zones of casein hydrolysis.

Two strains of *E. histolytica* (large race *HUS*-105 and small race Washington) hydrolysed casein. However, the supernatant from the fourth washing and the cultures of the associated bacteria did not hydrolyse casein. The amœbic casease was destroyed by heating at 65° C. for 5 min. but not by a temperature of 55° C. for 5 min. The enzyme activity at varying *p*H values was studied, and it was found to be active between *p*H 5 and *p*H 8. Thus, another proteolytic enzyme is established in *E. histolytica*. These experiments on the proteolytic activity of the amœbæ[2–4] may eventually yield clues on the mechanisms of pathogenicity of this important parasite.

This work was supported (in part) by the Office of Surgeon General, Department of the Army, Contract No. *DA*-49-007-*MD*-711.

MITSURU NAKAMURA
PHILIP R. EDWARDS, JUN.
Department of Bacteriology,
Montana State University,
Missoula, Montana.
Nov. 25.

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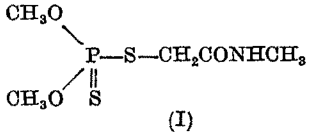
Mode of Action and Biological Properties of the S-(Methylcarbamyl) Methyl O,O-Dimethyl-Dithiophosphate

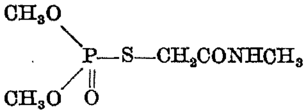
PREVIOUS investigations have demonstrated that S-(methylcarbamyl) methyl O,O-dimethyl-dithiophosphate (I), which possesses a peculiar insecticidal and systemic activity, very effectively controls the olive fly (*Dacus oleae* Gmel.)[1,2], the olive moth (*Prays oleellus* F.)[3], the cherry fruit fly (*Rhagoletis cerasi* L.)[4] and many other important pests. It was of interest, therefore, to investigate the metabolic behaviour and biological properties of this insecticide.

Experiments carried out by means of paper chromatography have demonstrated that oxidation of compound (I) by potassium permanganate and by hydrogen peroxide produces some derivates. Among them one component has been isolated, purified (by means of 100-tube Craig countercurrent distribution) and identified: the S-(methylcarbamyl) methyl O,O-dimethyl-thiolphosphate (II). The low R_F values of the spots and other evidence suggest that the other products of the oxidation of compound (I) are due to hydrolysis (possibly O,O-dimethyl dithio- and thiol-phosphoric acids). Metallic ions (Fe^{3+} Cu^{2+}, Zn^{2+}) catalyse the conversion of dithiophosphate (I) to thiolphosphate (II).



$$\mathrm{(CH_3O)_2P(=S)-S-CH_2CONHCH_3}$$

(I)



$$\mathrm{(CH_3O)_2P(=O)-S-CH_2CONHCH_3}$$

(II)

The same transformation has been shown to occur, at least partially, *in vivo* in plants such as broad beans, after root absorption of the insecticide, and in cherries, picked from sprayed trees; and *in vitro* in animal tissues, by incubating the insecticide (I) with mouse liver. Other derivatives (possibly products of hydrolysis), besides the thiol metabolite (II), from hydrogen peroxide oxidation of compound (I), were not found in the paper chromatographed tissues.

A gradual reduction in the amount of compound (II), obtained by chemical synthesis and applied to broad beans and cherries in the same conditions as insecticide (I), was demonstrated by paper chromatography and bioassay, but no evidence was obtained on the conversion of this compound to other derivates.

Toxicological researches indicate that the thiolphosphate (II) is a much stronger esterase inhibitor than the dithiophosphate (I): 185 times as effective as bovine cholinesterase inhibitor and 883 times as effective as house fly (*Musca domestica* L.) cholinesterase inhibitor. Nevertheless, compound (II) is only four times as toxic as (I) to mice by oral administration.

The insecticidal activity of both substances (I) and (II), tested on 11 species of insects, is nearly equal; the small differences being related to species and stages of insects and methods of testing. This suggests also that insects may metabolize the dithiophosphate (I) to thiolphosphate (II). On the other hand, the two substances possess different acaricidal activities: compound (II) is about 38 times as toxic as (I) to adults of *Paratetranychus pilosus* Can. and Fanz.

Finally, studies on systemic properties have been conducted. Both products, when applied to roots, stems or leaves of beans are absorbed and translocated to other parts of the plants in amounts lethal to the test mites (adults of *Tetranychus telarius* L.) feeding on untreated parts of the same plants. Furthermore, both compounds penetrate from the outside to the inside of fruits and exert a lethal effect on some species of fruit-eating larvæ.

Detailed results will be published elsewhere.

R. SANTI
P. DE PIETRI-TONELLI

Istituto Ricerche Agrarie,
Società Montecatini,
Signa, Florence. Nov. 28.

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α-Tocopherol and Hyaluronidase *in vivo*

THE description of exudative diathesis in chicken by Dam[1] indicates a considerable degree of capillary damage. In a further publication[2] he attributed this to a deficiency of α-tocopherol.

Reports[3,4] on the interaction of α-tocopherol and hyaluronidase suggested to me that, apart from its anti-oxidant activity, α-tocopherol might be involved in the protection of inter-cellular cement substance. Thus, in the condition described by Dam, the exudation could be due to the effect of hyaluronidase acting on the inter-cellular cement substance of the capillary walls and surrounding supporting tissues without the restraining influence of adequate α-tocopherol.

We divided twelve chickens into three groups of four each. Group 1 was fed a basal ration low in vitamin E and containing 17 per cent protein, 3·3 per cent fat, 1·3 per cent calcium, 0·8 per cent phosphorus and 0·5 per cent added sodium chloride; group 2 received the same ration plus 14 I.U. vitamin E/lb. fed as added 'Rovimix' (F. Hoffman, La Roche et Cie.); group 3 a normal commercial ration. After 5 weeks on these diets two birds in each group were injected intraperitoneally with a commercial brand of hyaluronidase 'Rondase' (Evans Medical Supplies, Ltd.). Each bird received 6,000 I.U. daily for 7 days. On the eighth day the birds were killed together with the control uninoculated birds, and Table 1 shows the results of post-mortem examination.

Table 1

Group	Control birds (no hyaluronidase)	Birds injected with hyaluronidase
1	Slight hæmorrhages in muscles	Hæmorrhages and advanced exudative diathesis
2	Normal	Normal
3	Normal	Slight hæmorrhages in muscles

These results indicate that *in vivo* β-tocopherol can act as a regulator of hyaluronidase activity.

ELIZABETH A. IRVING

Institute of Medical and Veterinary Science,
Frome Road,
Adelaide. Nov. 20.

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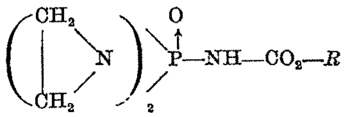
'Dual Antagonists'; Alkyl N-(*bis*-(ethylenimido)phosphoro)-carbamates; a New Series of Anti-Tumour Agents

THE concept of combination chemotherapy in the treatment of neoplastic diseases has been receiving considerable attention during the past few years. Some see the only theoretically possible solution to the problem of cancer chemotherapy in the simultaneous use of several synergistic drugs blocking several consecutive and/or alternative metabolic pathways, while others vigorously object to this thesis, from practical considerations or disappointing experiences.

One of our three collaborating research groups has been particularly interested in the chemotherapeutic potentialities of 'dual antagonists'[1], that is, chemical compounds incorporating the structural features of two different antimetabolites into a single molecule. 'Dual antagonists' are designed to synchronize the action of the synergistic components and thus overcome differences in absorption, distribution, or elimination that would negate or weaken any potentiation arising from simultaneous block of metabolic pathways at several points. If two inhibitors, directed against the same biochemical mechanisms or cellular structures but possessing different degrees of selectivity, are coupled chemically, the more selectively localizing component may prevail in directing the distribution of the molecule as a whole. As a result, the less selective (but often more potent) component may reach concentrations at the desired point of attack that could not be attained by the free (uncoupled) inhibitor below its toxic dosage. In particularly favourable cases, both synergistic components may be released at the desired point of attack gradually and simultaneously, providing for a prolonged local action.

Compound 1 of this communication unites the *bis*-(ethylenimido)-phosphoro radical, a bifunctional group known to have biological 'alkylating' activity, through an amide linkage to urethane, an antimetabolite of nucleic acid biosynthesis[2,3]. The carcinostatic effect of urethane is reported to be synergistic with the similar effect of biological alkylating agents[4].



1, $R = C_2H_5$ ('*AB*-100')
2, $R = CH_3$ ('*AB*-101')
3, $R = CH_2—C_6H_5$ ('*AB*-103')

In compounds 2 and 3, the same alkylating radical is linked to methyl and benzyl carbamate, respectively. Although the latter carbamates, as such, are not known to be effective antimetabolites, it is thought possible that when linked to the electron-attracting phosphoro-group they may split to yield the same active intermediate as urethane.

Compounds 1 and 2 were synthesized by treating dichloro*iso*cyanatophosphine oxide[5] first with ethyl alcohol (or methyl alcohol) and then with ethylenimine in the presence of a hydrogen chloride acceptor. Compound 3 was prepared by heating compound 1 in the presence of benzyl alcohol. All three compounds are white solids which can be crystallized from a mixture of benzene and cyclohexane: m.p.: 1, 88–90°; 2, 119–21°; 3, 134–35° C.

Compounds 1 and 2 are readily soluble in water, but decompose slowly in aqueous solution. In the animal experiments reported below, these two compounds were used in freshly prepared aqueous solutions, while compound 3 was injected in aqueous suspension or, intramuscularly, in peanut oil.

Acute intravenous toxicity tests in *ICR/Ha* Swiss mice gave the following *LD*50 values (mgm./kgm.): 1, 69·4; 2, 62·3; 3, 80·0. The corresponding values after intraperitoneal and subcutaneous administration are the same or only slightly higher, indicating rapid absorption. All deaths occurred between 4 and 9 days after the single injection. Histopathological studies indicated lymphoid involution.

Only a brief outline can be given here of the anti-tumour evaluation of compounds 1, 2 and 3; details will be published elsewhere. Eleven mouse and rat neoplasms were used in this work, and the new compounds were directly compared with nitrogen mustard under a variety of experimental conditions. In doses of equal toxicity, the three compounds were superior or equal to nitrogen mustard. In most cases, compound 3 demonstrated the highest activity, followed by compounds 1 and then 2.

In mice, all three compounds were active in the 'standard' sarcoma 180 test; average *T/C* ratios of 32 per cent by tumour diameter measurement, and 3–4 per cent (0·03–0·04) by tumour weight, were obtained. In different types of experiments with sarcoma 180, *ICR/Ha* Swiss mice were inoculated with known numbers of ascites tumour cells (*a*) subcutaneously and (*b*) intraperitoneally; in all experimental situations, the new compounds caused highly significant inhibitions of (*a*) tumour growth, and (*b*) ascites formation, respectively. Compounds 1 and 3 were also highly effective against Ehrlich ascites tumour and adenocarcinoma 755. In a number of transplanted leukæmias, definite prolongation of life was obtained with compounds 1 and 3; in others, prolongation of mean life-span was of borderline or no statistical significance. Many animals in the latter groups lived much longer than any untreated animals, but many died earlier, presumably because of drug toxicity in a state weakened by disease. This results in increased standard deviation. In *DBA*/2 mice inoculated with leukæmia *L*1210, four animals (out of 50) treated with compound 3 survived 90 days after inoculation and showed no sign of disease when killed and autopsied after this time. In our hands, no other chemotherapeutic agent produced similar apparent cures in any mice inoculated with this leukæmia. In *C3H* mice with 'spontaneous' mammary tumours, highly toxic doses of compound 3 (which actually killed all animals within 2 weeks) caused regression of existing tumours; lower, non-toxic doses inhibited tumour growth.

In rats, all three compounds completely inhibited the growth of Walker carcinosarcoma 256 tumours, at well-tolerated dosage-levels. In Dunning rat leukæmia, all three compounds, administered only during the first 12 days after implantation of the tumours, caused complete inhibition of tumour growth and apparently cured all animals. When they were re-inoculated with the tumour after 42 days, all developed tumours and died with leukæmia. In the control animals, tumours appeared on the eighth day after implantation and all animals died with leukæmia on the eighteenth–nineteenth day. Even when the treatment was delayed until the sixteenth day after tumour implantation, when the average size of tumour had reached 3·5 cm. and the white-cell count was about 70–90,000, compounds 1 and 3 still caused regression of all visible tumours; however, in this case, the tumours re-appeared after the treatment was discontinued, and the animals died.

Twenty-five patients with various advanced neoplastic diseases have been treated with compound 1. There was a remarkable absence of gastro-intestinal side-effects. The only side-reaction resembling those of known alkylating agents was depression of bone marrow. It is too early to evaluate the therapeutic results in these patients, although there are indications of anti-tumour effects.

THOMAS J. BARDOS
ZINON B. PAPANASTASSIOU
Research Division,
Armour and Company, Chicago 9.
ALBERT SEGALOFF
Alton Ochsner Medical Foundation and
Department of Medicine,
Tulane University,
School of Medicine, New Orleans.
JULIAN L. AMBRUS
Roswell Park Memorial Institute and
University of Buffalo,
Medical and Graduate Schools,
Buffalo, New York. Nov. 25.

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Fluorescence of Tissue Culture Cells stained with Acridine Orange

ARMSTRONG[1] has shown that biological fluorochrome acridine orange under controlled conditions of *p*H differentiates in fixed tissues betwen deoxyribo- and ribo-nucleic acids, the former showing green fluorescence and the latter red. Schummelfeder, Ebschner and Krogh[2], who examined the nature of this specificity, have shown that acid or heat treatment of fixed tissue, prior to its staining by acridine orange, changes the green-yellow fluorescence of the nuclear matter to a copper-red colour similar to that given by ribonucleic acid in the cytoplasm. From their observations the authors suggested that the green and red shades of fluorescence of acridine orange are associated with high and low molecular-weight forms of the nucleic acids. The deoxyribonucleic acid within the nucleus, however, is characterized by: (*a*) high degree of polymerization and (*b*) high level of orientation, which includes its double-stranded form and the structural organization within the chromosomes. The inquiry conducted by Schummelfeder *et al.* does not indicate the level of depolymerization necessary for the change in fluorescence. It does not also completely eliminate the significance of orientation in the specificity of greenish fluorescence usually shown by chromatin matter within the nucleus stained by acridine orange.

We have made observations on the fluorescence given by some tissue-culture cells stained by acridine orange prior to, and after, their exposure to different dosages of X-rays. Intestine, HeLa, HeLL and conjunctiva cells were grown in basal Eagle's medium on slips in flat test-tubes. After 24 hr. incubation, the slips were transferred to standard veronal buffer (*p*H 7·3) and irradiated with X-rays (International G.E.C., 200 kV., 100 m.amp.; 160 r./min.) up to a maximum dose of 4,000 r. The cells were fixed immediately in 3 per cent formalin, then transferred to a buffer medium of the desired *p*H, and later stained with acridine orange solution in the same buffer at *p*H 3–6 and concentration 0·05 per cent. The non-irradiated cells were given the same treatment as irradiated ones. The fluorescence of the stained material was observed with blue-violet excitation by using the mercury arc lamp with Reichert blue filter No. 8027 at the source and minus blue filter No. 8006 at the eyepiece.

In the non-irradiated cells all the nuclei showed green fluorescence with nucleoli yellow. The cytoplasm showed crimson red fluorescence. On X-ray irradiation the red fluorescence of the cytoplasm did not show much change except slight intensification. The green-yellow fluorescence of the nuclei also did not show much change until the irradiation dose exceeded 2,000 r. There was, however, a marked change from green towards red when the dose was increased above 2,200 r. and no nucleus with a green fluorescence was left over on the slip, when the dose was greater than 3,200 r. Thus the change of nuclear fluorescence did not appear to be a gradual process but was distinctly confined to a narrow dose-range between 2,000 r. and 3,000 r. These results indicate that in the mechanism that shifts the observed nuclear fluorescence within cells, some step or steps that respond to a cumulative or multihit action of ionizing radiations are involved.

The depolymerization of deoxyribonucleic acid by ionizing radiations has been studied in the solution state by Butler[3], Conway[4] and Daniel, Scholes and Weiss[5]. Their observations indicate that in the aqueous solutions the immediate action on depolymerization of deoxyribonucleic acid by X-rays is very feeble although more significant 'after-effects' are seen. No results concerning the dose effect relationship for the after-effects are yet available. Under the conditions of the present experiments, however, depolymerization studies in the solid state of deoxyribonucleic acid seem to be more important; for the deoxyribonucleic acid within the cells is considered to be localized within their chromosomal structures, which are often characterized by their gel state containing about 30 per cent solid matter[6].

Observations on the depolymerization of deoxyribonucleic acid in the solid state by ionizing radiations have been reported by Alexander and Stacey[6]. Their studies do not indicate a multi-hit mechanism for the breaks in the main chain of deoxyribonucleic acid. Besides, on the basis of their results, an estimate of the drop in the average molecular weight of deoxyribonucleic acid at 3,000 r. does not amount to even 1 per cent. We are therefore tempted to conclude that the green fluorescence of deoxyribonucleic acid stained by acridine orange is associated with some more labile character, such as its native state, not affected by formalin fixation, rather than simply its high polymer nature.

Beers, Hendley and Steiner[7] have recently shown the formation of two types of complexes between acridine orange and nucleic acids. Complex I involved the bases and inter-nucleotide phosphates of ribonucleic acid. Complex II, however, involves the terminal phosphates of both ribo- and deoxyribo-nucleic acid. They further state that the green fluorescence of nuclei is the result of the formation of complex II with deoxyribonucleic acid and the red fluorescence of ribonucleic acid is due to the formation of the mixture of complexes I and II involving greater take-up of the dye. The critical level of irradiation observed by us might be causing some intramolecular disorientation of deoxyribonucleic acid, involving inter-nucleotide bonds, so exposing additional sites for subsequent binding with acridine orange .

It may be noted that Puck, Marcus and Cieciura[8], in their experiments on clonal growth of mammalian cells by feeder layer technique, observed complete suppression of multiplication among the population of 2×10^5 HeLa cells with an X-ray exposure of 4,000 r. They also found that these irradiated feeder cells, though unable to multiply themselves into colonies, showed otherwise active metabolism.

We are indebted to Dr. J. A. Armstrong of the National Institute for Medical Research, London, for his helpful criticism. Thanks are also due to Mr. C. V. Bapat, Tissue Culture Department, Indian Cancer Research Centre, Bombay, for the provision of tissue culture cells, and to Mr. A. D. Rahalkar, Radiology Department, Tata Memorial Hospital, Bombay, for his help in irradiating the cells. One of us (U. N. J.) expresses his gratitude to the Council of Scientific and Industrial Research, India, for the award of a research fellowship which enabled him to carry out this work.

U. N. Joshi
K. S. Korgaonkar

Biophysics Department,
Indian Cancer Research Centre,
Bombay, 12.
Nov. 27.

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Phenolic Acids as Growth and Germination Inhibitors in Dry Fruits

The presence and chemical composition of substances in fleshy fruits which inhibit germination and growth have been studied by several workers[1-3]. On the other hand, the chemical nature of the inhibitors in dry pericarps is but little known[4,5]; thus their detailed examination seemed to be justified.

The water- and ether-soluble inhibiting substances in fruits of twenty-four species (for example, capsulas, legumes, siliquas) were examined with paper chromatography together with bio-assay, then chemically identified. The identification was made on the basis of R_F values, ultra-violet fluorescence, colour reactions and comparison with synthetic compounds.

According to the results inhibitors are present in all the fruits examined. The inhibiting substances are localized in two main areas in the chromatograms. In the inhibiting zone, between R_F 0·0 and 0·35, many benzoic- and cinnamic-acid derivatives of lesser activity were found, such as large-molecule tannic acids, protocatechuic-, caffeic-, chlorogenic-, ferulic-, *p*-coumaric- and *p*-oxy-benzoic acids, and an unknown phenol derivative. From the inhibiting zone between R_F 0·55 and 0·75, strongly active salicylic acid and, in some cases, two unknown cinnamic acid derivatives were demonstrated. It may be supposed that isomers of the above-enumerated substances are also present on the chromatograms.

It is remarkable that all inhibitors, chemically identified from dry fruits, are phenolic acids or their depsides and polydepsides. These substances occur in various combinations and quantitative proportions in the different fruits, but are not specific. Comparing the inhibitors in dry fruits with those demonstrated from fleshy ones, a considerable conformity can be seen. This fact supports our earlier assumption that the occurrence of phenolic acids as inhibiting substances are common in higher plants.

The greater part of the inhibitors is washed out of the fruits which remain on the trees until the spring. The rate of the leaching depends very much on the structure of the pericarp and the chemical nature of the inhibitors. The results prove that storage in dry conditions has no effect on the quantity and quality of inhibitors in the fruits.

Details of this work will be published elsewhere.

M. Varga
E. Köves

Institute for Plant Physiology,
University of Szeged.
Nov. 19.

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Dose–Response Relationship in Radiation Leukæmia : the Marking Probit

Linearity (or non-linearity) of the leukæmogenic potency of radiations has been discussed extensively in the recent literature[1,2]. Experimental results are usually presented by plotting incidence in percentages versus dose on an arithmetical scale. A regression curve is then fitted for assessing a correlation between these variables. The form of a dose–response curve is apparently attracting more attention than the nature of the variables involved.

In any sample of susceptible individuals, some develop leukæmia as a response to irradiation at a given dose, others do not. The development of leukæmia is clearly an all-or-nothing effect, that is, a quantal response. This implies a distribution of susceptibilities within the sample. Susceptibility stands for our ignorance of all the factors upon which the development of leukæmia is dependent. From theoretical statistics, however, we know that quantal effects exhibit a sigmoid dose – response curve. Adequate statistical treatment therefore requires probit analysis. Probit regression curves fit experimental results on radiation leukæmias in *C 57 BL* mice[3].

The second variable is the dose. It may be satisfactorily defined by four parameters: magnitude, rate, fractionation and duration. Incidence of leukæmia has been shown to vary with these dose factors[4]. For probit transformation the distribution of susceptibilities must be approximately normal, or normalized by metametric transformation of dose (dosage). For *C 57 BL* mice, normalization can be effected by expressing the susceptibilities in terms of the logarithm of the dose; but nothing has been published about an appropriate dosage for radiation leukæmias in humans. In any event, the assumption that incidence is independent of dose factors is most probably inaccurate; and incidence in percentages and dose on an arithmetical scale are irrelevant variables.

An alternative can be introduced by assuming a linear correlation and looking for variables that possibly fit it. This approach has led us to define the marking probit as a working hypothesis. It is assumed that both lethal and leukæmogenic effects of radiation are independent quantal responses distributed in a population of hæmatopoietic mother-cells present in any irradiated mouse. This independence is supported by experimental evidence[5]. Let PM be the probability of any mother-cell showing the leukæmogenic response (marking) and PL the probability of the lethal response (death). The probability PA of a leukæmia being initiated in any irradiated mouse is assumed to be equal to the proportion of marked surviving mother-cells. This proportion is an estimate of the combined probability $PM(1 - PL)$. Hence $PA = PM(1 - PL)$. The probability of acute radiation death in mice and rats is related to the degree of hæmatopoietic destruction as shown by leucocyte counts[6,7]. To a first approximation, PL may be therefore estimated from the acute mortality percentage. Furthermore, the probability of any mouse developing a leukæmia PC (observed incidence in the sample) is dependent upon PA and the chances of own survival $(1 - PL)$. Thus $PC = PA(1 - PL) = PM(1 - PL)^2$. Hence $PM = PC/(1 - PL)^2$.

Values for PM have been calculated from Kaplan's and my own results. From Figs. 1 and 2 it can be seen that PM may be normally distributed on dose or logarithm of the dose. It is therefore called the 'marking probit', as percentages may be expressed in terms of probits. Available data do not provide statistical control of the best fit. It is interesting to note, however, that marking probits are independent of dose factors. They are exclusively a function of total dose. It may be concluded that successive doses are additive for the initiation of the leukæmogenic process but not for the ultimate development of radiation leukæmia. The distribution of marking probits suggests that leukæmogenesis may require more than a single critical molecular event, although such an event may be the initiating agent.

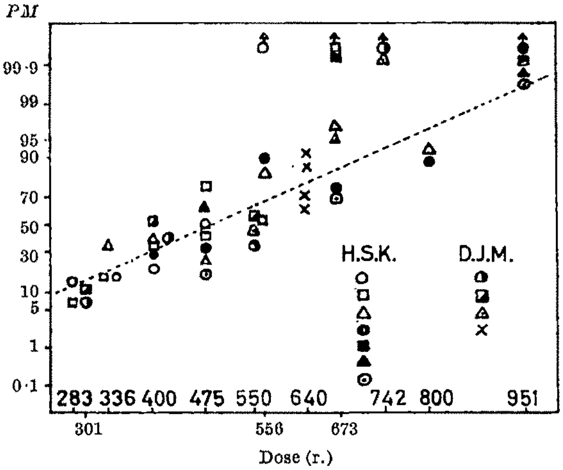

Fig. 1. Correlation between probability of a mother-cell showing the leukæmogenic response (PM) and total dose.
PM calculated from Kaplan's data: ○, single dose; □, 2 doses at one-day interval; △, 4 doses at one-day intervals; ●, 8 doses at one-day intervals; ◫, 4 doses at four-day intervals; ▲, 4 doses at eight-day intervals; ⊙, 4 doses at sixteen-day intervals.
PM calculated from my results: ◑, 2 doses at five-day intervals; ◪, 2 doses at five-day intervals + cysteamine; ◬, 2 doses at five-day intervals + cystamine; ×, 4 doses at seven-day intervals, with or without cystamine

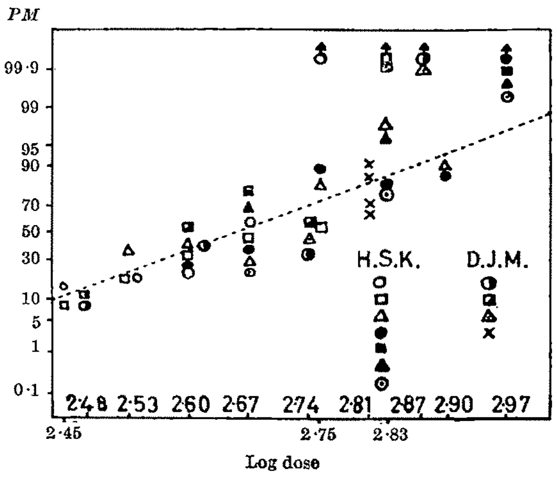

Fig. 2. Correlation between PM and logarithm of the dose

D. J. Mewissen

Institut Interuniversitaire des
Sciences Nucléaires,
University of Liège.

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Assimilation of Ammonia Nitrogen by Rumen Bacteria

Ammonia is always present in the rumen liquor of sheep[1] and the concentration varies with the kind of protein in the ration, but the addition of starch-rich foods such as maize meal or flaked maize to high-protein rations depresses the concentration[2–4].

The reason for this effect is not entirely clear; it is well known that the non-protein nitrogen of foodstuffs can, in part, substitute for protein in the ration, and this has led to the use of urea as a protein substitute in feeding cattle and sheep. There is evidence that nitrogen derived from urea can be assimilated by rumen bacteria when starch or maltose are present[5,6]. Assimilation of nitrogen-15 by mixed rumen organisms in the form of ammonia has been found[7], and variants of *Lactobacillus bifidus* isolated from the rumen are reported to assimilate ammonia nitrogen from the media[8].

The experiments summarized here were undertaken to examine the effects of different rations on the net changes of the ammonia content of rumen liquor and to obtain further information on the effects of starch on the possible assimilation of ammonia nitrogen.

The rumen liquor of sheep fitted with permanent rumen cannulæ and fed on various rations was withdrawn and incubated under carbon dioxide for 2–4 hr. at 37° C. Ammonium chloride was added to one of duplicate flasks to increase the initial concentration

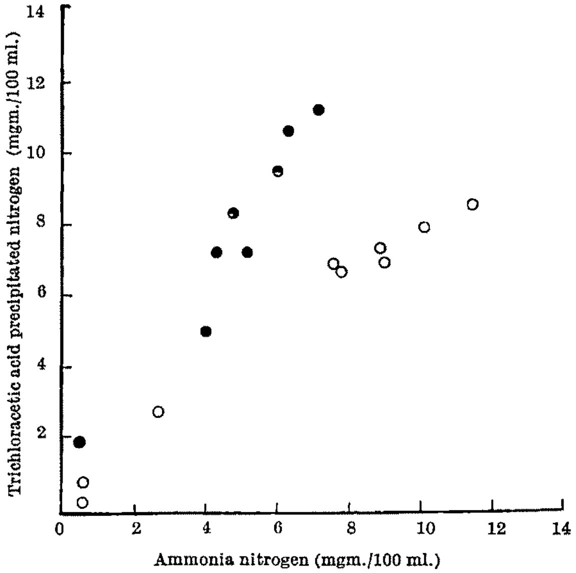

Fig. 1. The ammonia nitrogen lost from the media with peptone ● and without peptone ○ in relation to the nitrogen gained in the trichloracetic acid precipitate measured by direct determination using one culture incubated for periods of 12–96 hr.

of ammonia nitrogen by 40 mgm./100 ml. The total content of ammonia increased during incubation in the rumen liquor of sheep fed on grass or hay or sheep fed on hay with protein supplements. It decreased when the donor sheep were fed on hay with either fodder beet or a mixture of flaked maize and maize gluten meal. In the latter circumstances, the extent of the loss was variable and very occasionally did not occur. This was so if liquor was drawn before the first morning feed or if the sheep had a poor appetite, as occurred occasionally with the flaked maize ration. The loss of ammonia nitrogen from the rumen liquor of sheep fed the flaked maize ration was accompanied by an increase in the trichloracetic acid precipitate, and the use of ammonium chloride enriched with nitrogen-15 showed that ammonia nitrogen was concentrated in this precipitate. We are grateful to Dr. E. I. McDougall of this Institute for determining the concentration of nitrogen-15 in the various fractions before and after incubation.

A similar medium to that previously used[8] was devised containing starch and glucose in which ammonium chloride provided 87·1 per cent of the total nitrogen, *l*-cysteine 12·7 per cent and B vitamins 0·2 per cent. The whole was made up in a phosphate buffer, and trace elements were added. The media also contained acetate, a small quantity of citrate and 0·075 per cent agar. For solid media, the agar concentration was increased to 1·3 per cent. Liquid medium was gassed with oxygen-free carbon dioxide immediately after inoculation. Plates were incubated anaerobically under a gas phase of hydrogen containing 5 per cent carbon dioxide. Rumen liquor diluted in phosphate buffer was used for inoculating solid media and colonies were picked from plates and transferred to liquid media. Organisms isolated in this manner grew well. Isolates were obtained mainly from sheep fed on hay or hay and the flaked maize mixture with or without groundnut meal. *l*-Cysteine was essential for rapid growth. Replacement with thioglycollate allowed a less vigorous growth except when casein hydrolysate or methionine was added. *l*-Ascorbic acid or sulphide were ineffective even with methionine or casein hydrolysate. Growth did not occur in the presence of *l*-cysteine if ammonium chloride was substituted by sodium chloride. The majority of isolates were slender branching rods; but some coccal forms were also isolated. The general properties of all isolates were that starch and glucose were fermented with the formation of acetic and lactic acids and ammonia nitrogen was assimilated. The addition of peptone to the media caused more vigorous growth but ammonia nitrogen was still assimilated but to a less extent (Fig. 1).

The behaviour of cultures, however, was not always consistent, and after several subcultures some cultures produced ammonia when grown in the media with peptone, but after several further subcultures regained the property of assimilating ammonia nitrogen.

Additional examination of 28 isolates of the rod type showed that they all possessed the characters of lactobacilli; the sugars fermented were the same as those found for *Lactobacillus bifidus*[9]; the quantities of acetic and lactic acid formed were close to the ratio of 2 : 1; the lactic acid formed was found by Dr. T. M. Sutherland of this Institute to be the L(+) form. The morphological characters were also compatible with those described for *Lactobacillus bifidus*.

Table 1. THE MEAN LOGARITHM OF I + THE COUNT, WHEN THE COUNT IS GIVEN IN MILLIONS/ML., FOR SHEEP FED ON HAY (*H*), HAY AND GROUNDNUT MEAL (*H* + *G*), HAY WITH THE FLAKED MAIZE MIXTURE (*FM*) AND HAY WITH THE FLAKED MAIZE MIXTURE AND GROUNDNUT MEAL (*FM* + *G*)

	H	*H* + *G*	*FM*	*FM* + *G*	S.E. of difference (3 d.f.)
'Normal'	0·84	0·79	1·96	1·56	± 0·74
	0·81		1·76		± 0·52
'Peptone'	1·24	1·19	2·88	2·08	± 0·44
	1·21		2·48		± 0·31

Systematic plate counts of organisms in rumen liquor that would colonize on the media with or without peptone were made using eight sheep, pairs of which were maintained on one of the following rations: hay, hay with groundnut meal, hay with the flaked maize mixture and hay with the flaked maize mixture and groundnut meal. Four counts from each sheep were made over a period of four months and two sheep on different diets were sampled on each occasion. It was possible to eliminate differences between occasions when the results were analysed. Table 1 summarizes the results for the logarithm of I + the count with these occasional differences eliminated. It will be seen that using the medium with peptone ('Peptone') the rations containing the flaked maize mixture produced higher counts than the rations without this mixture ($P < 0{\cdot}05$). There is the same tendency with the counts made on the medium ('Normal') without peptone. The results with the 'Normal' media, however, are not significant, and this is probably due to one sheep in which no colony formation at all occurred on two occasions. The derived mean counts are given in Table 2. We are indebted to A. W. Boyne of this Institute for the statistical analysis of the results.

Table 2. THE MEAN COUNTS DERIVED FROM TABLE 1 IN MILLIONS/ML.

	H	*H* + *G*	*FM*	*FM* + *G*
'Normal'	11	10	151	60
'Peptone'	29	26	1,260	200

As colonies picked from 'peptone' plates had the property of assimilating ammonia nitrogen when grown in liquid medium, it appears as if the 'peptone' counts are more representative of the numerical importance of bacteria with this property than the more selective medium without peptone.

These experiments support the hypothesis that the depression in concentration of ammonia nitrogen that occurs when a starch-rich food is added to a high-protein ration may be due, in part, to an increase in the concentrations of bacteria that can assimilate ammonia nitrogen.

A. T. Phillipson
Marjorie J. Dobson
T. H. Blackburn

Rowett Research Institute,
Bucksburn, Aberdeenshire.
Nov. 28.

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β-Globulin Polymorphism and Early Fœtal Mortality in Cattle

Six β-globulin types have been found in British breeds of cattle by starch-gel electrophoresis[1]. Mating data showed that the six types represent the individual homozygotes and heterozygotes of three β-globulin alleles, β^{A}, β^{D} and β^{E}. Five of these six types were seen independently by Hickman and Smithies[2], who postulated a similar genetic mechanism.

It has been found that the proportion of the two possible types of offspring from some reciprocal matings is apparently influenced by the maternal genotype. Thus, from certain matings involving only the alleles β^{A} and β^{D} equal numbers of offspring like or unlike the mother (with respect to β-globulin genotype) would be expected. However, a consistent excess of offspring like the mother was obtained from such matings in both Friesian and Ayrshire cattle (Table 1). Although several of the calves in the results were sired by the same bull the effect was not correlated with particular bulls. Because of the practice of early disposal of bull calves from dairy herds the data relate only to female calves. It is not yet known if the same phenomenon occurs with male offspring.

In similar matings involving the allele β^{E} a preponderance of like-mother offspring was found when this allele was in the fathers' genotype only (Table 2). From the corresponding reciprocal matings where the mothers' genotype included β^{E} a consistent lack of β^{E} offspring was found.

Table 1. Reciprocal Matings showing an Excess of Like-Mother Offspring in Two Breeds of Cattle

Mating	Offspring (female calves from cows mated with A.I. bulls)			
	Friesian		Ayrshire	
Dam × Sire	Like dam	Like sire	Like dam	Like sire
$\beta^{AA} \times \beta^{AD}$	19	11	0	0
$\beta^{AD} \times \beta^{AA}$	13	8	12	3
$\beta^{DD} \times \beta^{AD}$	17	9	3	1
$\beta^{AD} \times \beta^{DD}$	32	25	1	0
Totals	81	53	16	4
Significance	$\chi^2 = 5\cdot85$; $P = 0\cdot01$–$0\cdot02$		$\chi^2 = 7\cdot2$; $P = 0\cdot01$–$0\cdot001$	

Table 2. Reciprocal Matings involving the Allele β^{E} (Results from Several Breeds Pooled)

Mating	Offspring (female calves from cows mated with A.I. bulls)	
Dam × Sire	Without β^{E}	With β^{E}
	Like dam	Like sire
$\beta^{AA} \times \beta^{AE}$	6	5
$\beta^{DD} \times \beta^{DE}$	22	11
	Like sire	Like dam
$\beta^{AE} \times \beta^{AA}$	5	1
$\beta^{DE} \times \beta^{DD}$	8	2

It is unlikely that these effects can be explained by differential production of gametes, by selective fertilization, by differential mortality in calfhood or by unwitting selection by the dairy farmer. The only simple explanation appears to be that the chances of survival of the bovine embryo are affected by the β-globulin genotype of the mother. Thus embryos differing in genotype from the mother appear to be less compatible with the mother than those of like type, except where the maternal genotype includes β^{E}. Then there seems to be antagonism between β^{E} dam and β^{E} embryo causing a dearth of β^{E} offspring. In this connexion it is significant that β^{E} is the least frequent of the three alleles in each breed examined, and is in fact absent in Jersey, Guernsey and South Devon cattle. A gene at a disadvantage in a balanced polymorphic system must have some counterbalancing advantage or it would be eliminated by natural selection. Whatever the nature of this advantage for β^{E} it is presumably greater for northern breeds of British dairy cattle than for southern because the β^{E} frequency increases steadily northwards[1].

Because of the low frequency of β^{E} the losses due to the postulated antagonism between β^{E} dam and embryo would be numerically small. However, the losses due to the lack of unlike-mother offspring (Table 1) from matings involving β^{A} and β^{D} could be quite important. Assuming that one-third fewer unlike-mother offspring are produced, it can be calculated that when the frequencies of β^{A} and β^{D} are 0·5 and β^{E} nil, only 83 per cent of conceptions would result in viable offspring if there were no other causes of prenatal loss. This percentage will increase as the disproportion between the frequency of β^{A} and β^{D} increases.

Robinson has used data from several sources to compute the estimated extent of prenatal loss in the cow[3]. He concludes that 10 per cent of services to cows in œstrus do not result in fertilization, while the products of conception from 27 per cent die during the first three months of gestation. Data published by the Milk Marketing Board[4] indicate a consistent loss of about 12 per cent of fœtuses between the first and third months of pregnancy. The loss was unaffected by season for three years, although the overall conception-rate showed seasonal variation. This 12 per cent loss is in close agreement with the estimated average of 86–88 per cent viability due to mother – fœtus β-globulin incompatibility.

From these results one would expect a greater percentage of viable offspring from crosses between homozygous bulls and cows of the same genotype, β^{E} individuals excluded, than from other crosses. Data to check this are now being collected.

I am indebted to Drs. P. M. Sheppard and A. W. H. Braden for helpful suggestions and criticism.

G. C. Ashton*

Animal Health Trust,
Farm Livestock Research Centre,
Stock,
Essex.

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* Present address: C.S.I.R.O. Sheep Biology Laboratory, Prospect, N.S.W., Australia.

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Juvenile Hormone in Thymus, Human Placenta and other Mammalian Organs

The development of methods for extracting and assaying the juvenile hormone of insects[1] has encouraged a search for the same biological activity in animals other than insects. Schneiderman and Gilbert have reported the first progress in this direction. Ether extracts of various invertebrates, including Hydrozoa, Polychaeta, Oligochaeta, Holothuroidea, Balanoglossida and Decapoda, give positive tests for juvenile hormone when assayed on pupæ of the silkworm, *Antheraea polyphemus*[2]. Equally surprising is the demonstration of juvenile hormone activity in certain crude aqueous extracts of bovine adrenals[3].

These extraordinary findings suggested the need for a more complete census of the distribution of juvenile hormone activity among mammalian tissues and organs. Our present purpose is to report that most, and perhaps all, mammalian tissues contain demonstrable amounts of a substance the biological activity of which in the insect assay is indistinguishable from that of juvenile hormone.

Our initial studies were performed on 1-day-old rats which were anæsthetized and blended at room temperature in 3 : 1 diethyl ether–ethanol. After washing with water and evaporation of the solvent, a golden oil was obtained which gave positive tests for juvenile hormone.

Afterwards, we took advantage of the fact that desiccated pulverized preparations of individual bovine organs are commercially available from the H.M. Chemical Co., of Santa Monica, California, and the Nutritional Biochemicals Corporation of Cleveland, Ohio. 50-gm. samples of ten of these pulverata were blended and extracted at room temperature with diethyl ether, and the extracts washed several times with water. After evaporation of the solvent, the oily extracts were tested for juvenile hormone activity by a modified version of the 'wax test' described by Schneiderman and Gilbert[2,3]. In brief, a zone of cuticle, about 1 mm. square, was excised from the thoracic tergum of a previously chilled *A. polyphemus* pupa. The oily extract was applied topically to the exposed epidermis and the latter then capped and sealed with melted wax. If the extract contains juvenile hormone, a patch of pupal cuticle forms under the wax wound during the pupal–adult development[2,3].

Positive tests were obtained for extracts of the following pulverata: thymus, bone marrow, placenta, ovary, corpus luteum and adrenal cortex. Liver, testis, kidney and spleen gave negative tests.

The extracts were chromatographed on alumina columns by precisely the same techniques that fractionate juvenile hormone in extracts of insect material. The individual fractions were dissolved in a small volume of peanut oil and tested by injection into *A. polyphemus* pupæ. After this purification, all extracts, including those that were formerly negative, gave positive test for juvenile hormone activity. Among the ten pulverata, thymus gave extracts of highest activity and adrenal cortex of next highest.

These results were confirmed and extended in the preparation of very active fractions from fresh calf thymus and liver, beef tenderloin and fresh human placenta. Positive tests were also obtained from preparations of deep-frozen pituitaries of sheep.

In contrast to these uniformly positive findings on mammalian organs, we have failed to detect any trace of activity in wheat-germ oil, soy-bean oil or extracts of dried brewer's yeast.

Extracts of commercial lard gave negative tests. However, we can report that substantial activity is found in purified extracts of ordinary heavy cream and in products prepared from cream. In contrast to this, extracts of powdered skimmed milk are inactive.

In summary, the picture that takes shape reveals a very broad distribution in the mammalian body of a factor which is indistinguishable from the juvenile hormone of insects. In view of the extraordinary biological activity of this hormone on the growth, metamorphosis and aging of insects, it seems important to decide whether the juvenile hormone may play a part in mammalian physiology or whether its presence in higher forms is something of a biochemical curiosity.

This investigation was supported in part by a research grant from the Division of General Medical Sciences of the United States Public Health Service.

Carroll M. Williams
Lynn V. Moorhead
Jean F. Pulis

Biological Laboratories,
Harvard University,
Cambridge 38, Mass.

Nov. 24.

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Recovery of Injected Progesterone and its Relation to the Onset of Human Labour

The conception that progesterone is the hormone responsible for the maintenance and therefore secondarily also for the onset of labour is based on several important findings: the indispensability of the corpus luteum for pregnancy in the rabbit[1]; the extraction of the effective substance from corpora lutea[2]; the role of progesterone in the implantation and early development of the fertilized ovum[3]; the excretion of progesterone as urinary pregnanediol and the relation between pregnanediol output and the prognosis of pregnancy[4]; finally, the elucidation of the mechanism of the endocrine control of the pregnant rabbit uterus[5–7].

In the rabbit the indispensability of progesterone for the maintenance of gestation is thus definitely proved. In the human, however, the role of progesterone in the maintenance and termination of pregnancy is much more obscure: it is not possible to prevent premature labour[8] and to prolong pregnancy[9] by means of progesterone administration; the increasing sensitivity of the myometrium to oxytocin at the end of gestation is not suppressed by progesterone injection[10]; the level of serum progesterone[11] and the excretion of pregnanediol[12] do not drop until after delivery.

It has, however, been reported[13] that in the first half of normal human pregnancy more than 20 per cent of administered progesterone is excreted as urinary pregnanediol, while less than 20 per cent is excreted in pregnancies which end in spontaneous abortion. A similar relation between myometrial reactivity and progesterone recovery was suggested by recent experiments made by me[9] on legal abortions by means of intra-amniotic formalin injections. Therefore, I supposed that such a relation may also exist in other cases of reactive myometrium, for example, prior to labour. No earlier investigation of progesterone recovery at the end of gestation has been reported.

Twenty-five normal and healthy women in different stages of pregnancy received 200–400 mgm. progesterone ('Proluton', Schering) as a single intramuscular injection. The urine was collected in 24-hr. samples, generally for 10 days, that is, 2–3 days before and 6–7 days after progesterone injection. Pregnanediol was determined according to Jensen's method[14]. By this method only pregnanediol (free and conjugated) is determined. The average pregnanediol excretion during 2–3 days before progesterone injection was taken as pre-injection blank. If labour occurred earlier than 3 days after progesterone injection, the period of observation was assumed to be too short; hence these cases were excluded.

In the first 36 weeks of pregnancy the recovery of injected progesterone was found to vary between 19 and 38 per cent with an average of 27 per cent (Table 1).

Table 1. Recovery of Progesterone as Urinary Pregnanediol before the Thirty-sixth Week and during the Two Last Weeks of Pregnancy

Length of gestation (weeks)	No. of cases	Progesterone recovery (per cent)	
		Range	Average
≤ 36	10	19–38	27
39–40	15	0–13	3

The large amount of endogenous pregnanediol excreted at the end of gestation and the great daily variations in the excretion cause some difficulties in calculating the recovery of progesterone during this period. In order to facilitate the calculation of recovery, large doses of progesterone were given (in most cases 400 mgm.). If, as in the first 36 weeks, 20–40 per cent of exogenous progesterone had been excreted (that is, 80–160 mgm. pregnanediol), this increase in pregnanediol output would necessarily have been observed. However, in the last two weeks of pregnancy no injected progesterone or only some few per cent were excreted (Table 1). It must therefore be concluded that a considerable decrease in recovery of injected progesterone occurs near term, apparently simultaneously with the increase in myometrial reactivity. This decrease in progesterone recovery may be due to: (1) a decrease in pregnanediol excretion and/or (2) a change in progesterone metabolism.

(1) A decrease in pregnanediol excretion would imply that the capacity of the kidneys to excrete pregnanediol is limited and that at term the upper limit is reached even before progesterone injection. If so, the excess of pregnanediol, produced by progesterone administration, must be excreted by some other route (the fæces ?). It is, however, difficult to understand why the upper limit should always be reached at the end of gestation, while it is never reached earlier in normal pregnancy, in both cases quite irrespective of the pre-injection level of urinary pregnanediol.

(2) A change in progesterone metabolism would mean that progesterone is transformed to metabolites other than pregnanediol. If so, the metabolic change may imply that neither endogenous nor exogenous progesterone ever reaches the myometrium as an effective substance. In this way the 'progesterone block'[5] is withdrawn as effectively as if the progesterone production had ceased. The difference between the rabbit and the human pregnancy, in respect of the endocrine control of the pregnant uterus, seems to be that in the rabbit only the amount of progesterone is of crucial importance, while in the human not only the amount but also the metabolism of progesterone are vital.

The relation between recovery of progesterone and myometrial reactivity, the nature of the decrease in recovery and the problem of other sources of urinary pregnanediol are now undergoing further investigation in our clinic.

LARS PH. BENGTSSON
Obstetrical and Gynæcological Clinic,
University of Lund,
Sweden. Dec. 17.

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Discrepancy between the Distributions of Iodine in Human Serum when estimated by Iodine-131 and Iodine-127

IN spite of indications to the contrary[1], it is generally assumed that only traces of iodotyrosines are normally present in circulating blood of human beings and animals[1,2]. This assumption is based on the distribution of the labelled iodoamino-acids observed after administration of iodine-131. Roche and Michel[1] state: "Thyroid hormone must be considered as being a mixture of L-thyroxine and L-3,5,3′-triiodothyronine and containing at least 90 per cent of the total plasma iodide". Previous work with stable iodine, however, suggests otherwise[3].

Recently, it has become feasible to determine the distributions of both the labelled[4] and the stable[5] serum iodine on the same chromatogram. Initial observations suggested a marked discrepancy between the distributions obtained by the two methods, as well as an unsuspectedly long equilibration period for iodine-131. These findings made in euthyroid individuals have been extended in a larger series, with essentially the same result.

Table 1. Distribution of Iodine-131 in the Non-protein Fraction of Human Serum

Patients*	Days after iodine-131	Percentage iodine-131 in DIT	MIT	I^-	T_4	T_3
Ha.	1	<1	<1	96	4	1
	3	<1	<1	51	42	7
	7	1	1	14	61	24
	10	4	3	15	28	50
	17	3	5	30	43	19
Ro.	1	<1	3	96	<1	<1
	5	<1	3	86	8	3
	7	3	1	50	37	9
	10	1	3	17	71	8
Ta.	3	<1	2	48	50	<1
Br.	33	1	1	16	55	27

DIT, Diiodotyrosine; MIT, monoiodotyrosine; T_4, thyroxine; T_3, triiodothyronine.

* Clinical status and sex of the patients in this table are listed in Table 2.

Table 2. Distribution of Iodine-127 in the Non-protein Fraction of Human Serum

Patient	Clinical status	Sex	No. of bloods tested	Percentage iodine-127 in DIT	MIT	I^-	T_4	T_3
Ha.	coronary	M	4	30±4	27±2	5±1	29±2	9±3
Ro.	coronary	M	4	29±4	19±3	5±1	35±4	12±4
Ta.	healthy	F	1	15	38	6	34	7
Br.	healthy	F	1	30	28	9	23	10
Wi.	healthy	M	1	29	8	<1	57	6
Le.	healthy	M	1	24	14	<1	58	4
Kl.	healthy	M	1	36	35	<1	28	2
Ch.	healthy	M	1	22	32	2	15	26
Me.	healthy	M	1	26	28	4	29	12
Ave.				27	25	4	35	10

DIT, Diiodotyrosine; MIT, monoiodotyrosine; T_4, thyroxine; T_3, triiodothyroxine.

Blood for iodine-127 chromatography was secured from seven healthy medical students and older volunteers. Blood was also drawn for iodine-131 and iodine-127 chromatography from two euthyroid patients, nearly recovered from a coronary occlusion, following administration of 150 and 200 μc. of iodine-131 respectively and from two individuals following the administration of 125 μc. of iodine-131.

The results are presented in Tables 1 and 2. As expected, the greatest part of the radioactivity was present in the serum as iodide 24–48 hr. after labelling. After this, the activity appeared mainly in the thyronine fraction, although a sizeable proportion was present as iodide in all specimens studied. Very little iodine-131 was found in the tyrosine fraction, even 10 days after labelling.

In contrast, the iodine-127 measurements show that approximately half the circulating iodine was in the form of diiodotyrosine and monoiodotyrosine, half as thyronines, but virtually no iodide. The identity of the monoiodotyrosine and diiodotyrosine has been confirmed by one- and two-dimensional co-chromatography in the presence of the radioactive compounds, and also by the ceric sulphate – methylene blue reaction[5] with and without added standards.

The distribution of the serum-iodinated compounds estimated from iodine-131 labelling conforms well with the reports in the literature[2]. It is demonstrated in the present study, however, that equilibrium is not necessarily attained by 72 hr., as has been generally believed[6]. Thus it is clear that the time after labelling with iodine-131 is an important factor in the result, which must be considered in any evaluation or comparison of chromatographic data based upon radioactivity. Conclusions from much of the work in the literature may need reappraisal on this account.

The finding in this study that about one-half of the iodinated compounds in human serum is present as iodotyrosines when stable iodine content is measured is thus most surprising. Since the determinations of both iodine-127 and iodine-131 were made on the same chromatogram, and since the behaviour of both labelled and stable standards processed in the same way matched the compounds in serum, on one- and two-dimensional chromatograms, it is unlikely that the findings are due to artefacts[3].

A reasonable explanation for the discrepancy may be found in the fact that varying dilutions of the isotope must take place within the thyroid. There is approximately ten times as much iodine in the iodotyrosines as in the iodothyronines[5]. If each group of compounds were to be secreted into the blood on a 1 : 1 basis, the specific activity in the iodotyrosines would be one-tenth that of the iodothyronines. With the usual labelling doses of iodine-131 currently employed, this low level of activity would be regarded as not significant.

The effect upon thyroid function of a coronary occlusion in the two patients followed serially several weeks before the study with iodine-131 might account for the slow rate of incorporation of the isotope into the thyronine fraction. However, the iodine-131 values in the specimens obtained at 72 hr. in two healthy volunteers and serially in a euthyroid healthy patient not presented here with non-toxic diffuse goitre and the conformity between the iodine-127 values of the patients and those of the healthy subjects, suggest that the thyroids were normally active and that slow labelling is a normal event.

Since chromatography with iodine-131 does not reveal the true distribution of the stable iodine, it seems possible that determination of both radioactive and stable iodine distributions may be necessary if greater insight is to be obtained into the disturbed mechanisms underlying certain unexplained disorders of the thyroid such as sporadic non-toxic goitre.

Following this work, Dr. James Wynn, Veterans Administration Hospital, Durham, N.C., has also found discrepancies between the iodine-127 and -131 results using quite different methods for separating the iodocompounds.

We are indebted to Mr. Richard H. Mandl for his help with these experiments.

This work was supported by grants *A*-8 (*C*9) and *A*-1233 (*C*1 and 2), National Institutes of Health, Division of Arthritis and Metabolism.

SIDNEY C. WERNER

Department of Medicine,
Columbia University College of
Physicians and Surgeons and the
Presbyterian Hospital of the City of New York.

RICHARD J. BLOCK

Boyce Thompson Institute for Plant Research,
Yonkers,
New York.

Nov. 26.

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BIOLOGY

Functional Changes in the Vacuole-containing Bodies of the Gastric Parietal Cell

THE cytoplasmic inclusion known as the vacuole-containing body[1] was first found by Palade[2] in a study of the fine structure of the neurone and afterwards in tracheal, intestinal and renal tubular epithelia.

It consists of a cytoplasmic vacuole—0·2–1μ in diameter—bounded by a single membrane 60 A. thick, containing small circular vacuoles, 500 A. in diameter. No morphological changes have been hitherto described in vacuole-containing bodies and their function and nature are obscure.

Similar vacuole-containing bodies are found in the gastric parietal cells of the fasting mouse[3], where one or two are found in each section. They are smaller than the mitochondria, and consist of a vacuole—0·2–0·4μ in diameter—bounded by a single membrane, which contains a few small 500-A. vacuoles (Fig. 1*a*).

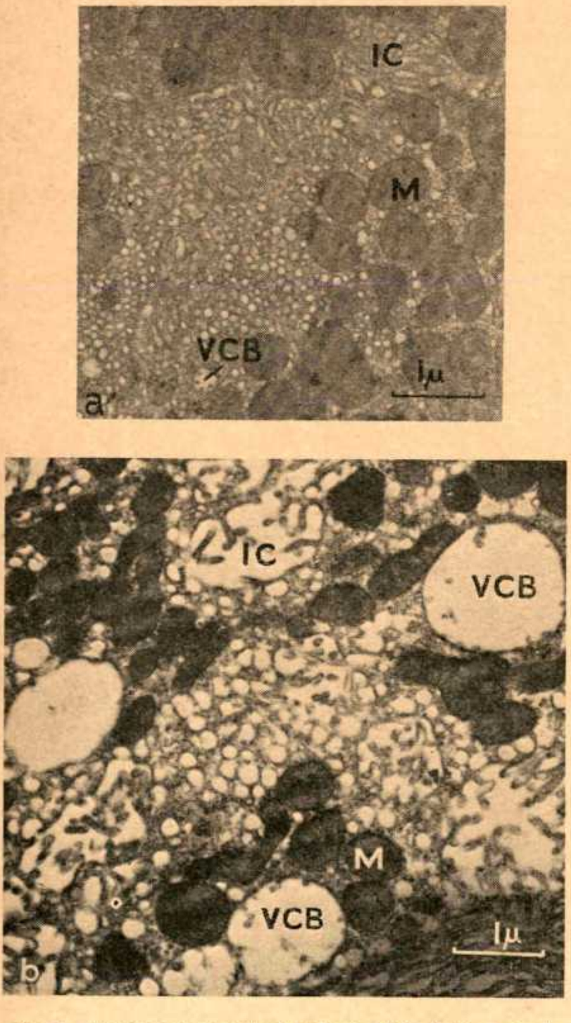

Fig. 1. Above: micrograph of parietal cell in fasting animal. A single small vacuole-containing body (*VCB*) is present. *IC*, intracellular canaliculus; *M*, mitochondria. (× 12,000). Below: micrograph of an actively secreting parietal cell. Several large vacuole-containing bodies (*VCB*) are visible. *IC*, intracellular canaliculus; *M*, mitochondria. (× 12,000)

Following repeated injections of pilocarpine nitrate, certain changes occur within the parietal cell. The vacuole-containing bodies become more numerous—about 5–7 occur in each section—and are much larger, namely, 0·5–3μ diameter. The small contained vacuoles are unchanged in size, although their total number has increased (Fig. 1*b*).

Thus in the gastric parietal cell the vacuole-containing bodies undergo marked morphological changes according to the secretory state of the cell. Phase-contrast microscopy of 2-μ sections confirms that these vacuoles are visible in the active parietal cell, and thus it should be possible, with routine histochemical methods, to elucidate the nature of this structure.

A. D. HALLY

Anatomy Department,
University of Glasgow.
Oct. 18.

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Induction of Lung Tumours by Radioactive Particles

INHALATION provides one of the most accessible routes for the entry of radioactive materials into the body. To evaluate the health hazards of airborne radioactive particles, it is important to know the biological effects of their deposition in the respiratory tract. When relatively insoluble particles are involved, pulmonary tissues may receive a large radiation dose because of a low rate of clearance from the lungs. The occurrence of squamous cell carcinomas as a result of the intratracheal injection of $^{239}PuO_2$ was initially reported from this laboratory[1]. Recently, malignant tumours were described in rat lungs after intratracheal administration of $Ba^{35}SO_4$ and $^{144}CeF_3$ (ref. 2), polonium-210 (ref. 3), and after implantation of strontium-90 glass beads and cylinders plated[4] with ruthenium-106. This communication concerns the occurrence of malignant lung tumours in mice after intratracheal administration of $^{106}RuO_2$ as well as $^{239}PuO_2$.

Suspensions of $^{239}PuO_2$ and of $^{106}RuO_2$ particles suspended in either 0·1 per cent 'Tween-80' (Atlas Powder Co.) or 0·1 per cent 'Pluronics' (Wyandotte Chemical Corporation) were administered intratracheally to two-month-old female BAF_1 mice. Barium sulphate particles were also given to a group of mice as an example of a known innocuous particle[5,6]. Stable ruthenium dioxide was administered to an additional group of control animals. The relative insolubility of $^{106}RuO_2$ and $^{239}PuO_2$ was shown in other experiments[7,8]. Approximately 20 per cent of the original dose was present in lungs after 100 days and 5 per cent after 400 days. The mice were killed either 100 or 500 days after treatment and examined grossly and histologically for pathological changes.

Grossly, two types of lesions were distinguished: pulmonary papillary cystadenomas and pneumonitis. The tumours were pearly white and frequently located near the pleura. These tumours were easily identified unless obscured by pneumonitis. The pneumonitis was bacteriologically sterile, and the affected lungs were pale with focal necrosis.

Table 1. INCIDENCE OF PATHOLOGICAL FINDINGS IN LUNGS AFTER INTRATRACHEAL INJECTION OF PARTICULATES

Material injected	100 days			350 to 500 days				
	No. of mice	Percentage with papillary cystadenomas	Percentage mice with pneumonitis	No. of mice	Percentage with papillary cystadenomas	Days after administration	No. and type of malignant tumour	Calculated dose (rad)
None	50	14	0·0	28	78	403–470	0·0	—
0·1 ml. distilled water	25	16	0·0	15	66	430–479	0·0	—
0·1 mgm. 'Tween-80'	25	8	0·0	18	39	386–513	0·0	—
5 μgm. $BaSO_4$	55	16	5·0	4	100	405	0·0	—
0·01 mgm. 'cold' RuO_2	46	28	7·0	21	9	335–500	0·0	—
3 μc. $^{106}RuO_2$	41	56	42·0	23	82	350	1 undifferentiated	9,000
1·93 μc. $^{106}RuO_2$	—	—	—	11	90	369–422	1 alveolar cell	4,000
0·15 μc. $^{106}RuO_2$	—	—	—	10	—	340	1 lymphosarcoma	300
0·06 μc. $^{239}PuO_2$	25	20	72·0	17	51	400	2 squamous cell carcinoma	2,300
0·003 μc. $^{239}PuO_2$	30	30	—	21	30	500	1 fibrosarcoma	115

The results of gross and microscopic examinations are given in Table 1. No demonstrable increase in the incidence of papillary cystadenomas was observed in animals treated with radioactive particles. At 100 days pneumonitis was not seen in controls but occurred only after administration of particles. Pneumonitis was observed in about 5 per cent of animals administered barium sulphate or ruthenium dioxide. After administration of ruthenium-106 and plutonium-239 pneumonitis was observed in 42 and 72 per cent respectively of the animals.

A marked increase in histological effects was observed at 350–500 days relative to the earlier period in mice given radioactive particles. Sections of lungs from mice killed 100 days after administration of 0·06 μc. $^{239}PuO_2$ showed foci of proliferation of bronchiolar epithelium and squamous metaplasia. These lesions were within foci of fibrosis which surrounded deposits of radioactive particles. After 400 days many grossly affected lobes appeared atelectatic and fibrotic. Such lesions showed a progression of the fibrosis and epithelial hyperplasia with associated tumour development as described below. The lungs of mice given ruthenium-106 grossly appeared hyperæmic with discrete areas of fibrosis. Microscopically, epithelial proliferation was not apparent, but areas of necrosis and fibrosis were observed. The latter contained cells with large, bizarre, hyperchromatic nuclei. Several malignant tumours occurred in mice given radioactive particles. These were found after administration of $^{106}RuO_2$ and included an undifferentiated anaplastic tumour, an alveolar cell tumour, and a lymphosarcoma. Two squamous cell carcinomas and a mediastinal fibrosarcoma were observed in mice given $^{239}PuO_2$.

Estimates of the total dose to lung tissue for the mice showing malignant tumours are included in Table 1. The dose values were derived by assuming uniform distribution of the material in the lung and exponential loss with an effective half-life of about 30 days for $^{106}RuO_2$ and $^{239}PuO_2$ administered intratracheally. Since non-uniform distribution of the particles was evident from autoradiograms, microscopic volumes of tissue received doses larger than those estimated. The lymphosarcoma in the lung and the mediastinal fibrosarcoma had the lowest estimated radiation exposure of 115 and 300 rad. The genesis of these tumours had a less-certain relationship to the deposition of radioactive particles. The lungs involved showed no evidence of radiation tissue effects at autopsy, and the cell types may be considered atypical for radiation-induced tumours in this location. The other doses exceeded 2,000 rad and are in the range of estimated radiation doses which caused malignant pulmonary tumours in experiments summarized in the report of the Sub-Committee on Inhalation Hazards of the National Research Council[9].

This work was performed under contract No. *W*-31-109-Eng-52 between the Atomic Energy Commission and the General Electric Company.

LEWIS A. TEMPLE
D. H. WILLARD
S. MARKS
W. J. BAIR

Biology Operation,
Hanford Laboratories,
General Electric Company,
Richland, Washington.
Dec. 8.

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Sexual Maturity in *Drosophila*

D. J. MERRELL[1] says in regard to the fertility of matings of *Drosophila* when employing males less than 24 hr. old and males aged for seven days: "The unaged flies were left together in the creamers for periods ranging from 18 to 72 hours; the aged flies were separated after 2 to 7 hours, the variation in time being due to differences in the length of time needed for fertilization to occur".

According to Bodenstein[2], formation of mature spermatozoa is initiated in the pupal stage around three days before emergence of the pupæ. But it is not until about 7 hr. after eclosion that the first motile sperms appear[3]. Thus a successful mating before this time is unlikely. However, observations of mating behaviour of young males indicate that they very infrequently mate before they are 12 hr. old.

It seems that young males, that is, 0–1 day old are more reluctant to mate than older males, that is, 3–4 days old. Thus, a personal communication from Lüning informs me that in tests he has made very small progenies are obtained from young males when the mating period is 60 min., compared with large progenies from older males. When the mating period is extended to 2–3 hr. even the young males have large progenies. Another observation by Lüning is that in the group with young males the first male copulated 30 min. after they were brought together with the females, while in the group with older males the first males had started mating already after 3 min.

That there are also strain differences in regard to rate of sexual maturity is indicated by the experiment described below.

Males 0–3 hr. old, but with fully stretched wings, were mated individually to single virgin hybrid females. When the males were 24 hr. old, they were given a new set of virgin females for another 24 hr. Then the males were discarded. The females were permitted to lay eggs for a 3-day period after the mating period. Later all vials were observed for hatched eggs. The experiment was carried out at a temperature of 25° C. Table 1 gives the results obtained for the two wild-type strains, Iso-Amherst and Oslo. These results indicate that there is a significant difference between these stocks regarding the frequency of successful cultures obtained from males 0–24 hr. old, but no significant difference when the males are 24–48 hr. old.

Table 1

Strains	First brood			Second brood		
	Total No. of cultures	No. of successful cultures	Successful cultures (percent)	Total No. of cultures	No. of successful cultures	Successful cultures (percent)
Iso-Amherst	117	42	35·9	112	98	87·5
Oslo	113	67	59·3	108	89	82·4

This would indicate that males from the Oslo strain reach sexual maturity at an earlier age than males from the Iso-Amherst strain.

For both strains there is a significant difference between successful cultures on the first and second day. This holds true for several wild-type strains tested.

ØISTEIN STRØMNAES

Institute of Genetics,
University of Oslo,
Blindern.

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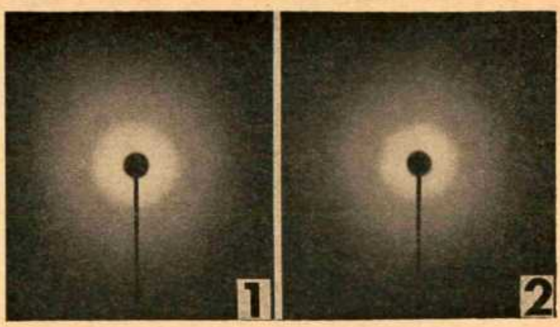
X-Ray Diffraction Patterns from the Egg Membrane of the Egg of the Brook Trout

STIMULATED by the findings of Young and Inman[1] and Brown[2] that the capsule of salmonid eggs can be classified as a pseudokeratin, we have recently made X-ray studies of the egg membrane of the brook trout, *Salvelinus fontinalis*. The membrane from the fresh unfertilized egg was washed with Ringer's solution to remove traces of egg contents and dried at room temperature. For analysis a Laue-type diffraction camera was used, with a flat film cassette 4·8 cm. from the specimen. The diagram obtained with copper K_{α} radiation, either vertical or parallel to the surface of the dry specimen, was a continuous halo with two main peaks at about 4·5 A. and 13 A. respectively (Fig. 1). As is also seen in Fig. 1, there is a sharp ring surrounding the whole halo. However, examination reveals that this ring coincides with the strongest line of sodium chloride, 2·81 A., and is wholly lost from membranes which have been washed with fresh water prior to desiccation. Consequently, it may be assumed that this ring pattern is not characteristic of the egg membrane, but is merely caused by adherent crystals of sodium chloride from the washing medium.



Figs. 1 and 2. X-ray diffraction diagrams of the egg membrane (vertical to the membrane surface). 1, Egg membrane of intact, unfertilized egg; 2, membrane taken from activated egg

As has been pointed out by various workers, salmonid eggs have a weak and fragile capsule until shed, but become much tougher, so-called water-hardened, at the time of fertilization or artificial activation[3–7]. As to the mechanism of such membrane hardening, Hayes[3] has suggested that it is a "special case of the reorganization of a protein molecule to form a keratin-like substance". It is of interest to see whether this idea is confirmed by changes in X-ray diagrams. Therefore, the egg membrane taken from eggs undergoing activation in fresh water was subjected to X-ray analysis. Contrary to expectations, the diagram was of similar halo type, giving no evidence of keratin (Fig. 2); no significant difference was found between the two diagrams by the microphotometric examinations. The present X-ray studies thus afford no proof of the change in the molecular organization of the egg membrane supposed to occur at the time of laying.

We are grateful to Prof. K. Niwa, Hokkaido University, and to Dr. T. Katsufuji, for their valuable suggestions and criticisms during the course of the present work.

MAMORU KUSA

Department of Biology,
Yamagata University,
Yamagata.

TSUGUYASU WADA

Chemical Institute,
Faculty of Science,
Hokkaido University,
Sapporo, Japan.

Nov. 7.

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Micro-Electrode Penetration of Ascites Tumour Cells

EHRLICH ascites tumour cells from mice were suspended in Krebs phosphate Ringer in agar and maintained at 37° C. in a small chamber. Ling–Gerard micro-pipettes were filled with 3 *M* potassium chloride. They had a tip resistance of 30–50 megohms, and were checked for tip potentials by Adrian's method[1]. Any showing tip potentials greater than 2 mV. were discarded. Penetrations were observed microscopically under a magnification of 600.

The input valve ('Hivac' *XE*2) and micro-pipette holder were carefully insulated from earth, the measured input resistance being greater than 10^{11} ohms. The grid current was less than 10^{-13} amp., the valve being biased above contact potential so that with the grid open, or the tip of the micro-pipette deliberately blocked by pushing it into the 'Vaseline' lining the bath, a negative potential resulted.

In general, a difference of potential of 5–10 mV., positive inside, appeared when the microtip just penetrated the cell wall. This difference of potential was stable and could be obtained repeatedly on successive impalements of the same cell. The microtip could be moved about inside the cell for a small distance without changing this difference of potential.

On pushing the microtip farther into the middle of the cell the difference of potential changed abruptly to a value of 20–40 mV., negative inside. This difference of potential remained constant for about 10 sec. and then declined slowly; small movements of the tip caused no further change. If the tip was withdrawn after one or two seconds, the sequence just described could be obtained several times in one cell.

Under favourable conditions the following sequence of events is observed. On bringing the microtip up to the cell a slight dimpling of the outer wall is seen. As penetration occurs this dimpling disappears and the cell seems to seal itself around the tip, as usually occurs with other types of tissue. At this stage a difference of potential of 5–10 mV. appears abruptly. As the tip is moved farther into the cell, an invagination appears in the interior granular material. This suddenly disappears and at the same time the potential difference changes abruptly to 20–40 mV., negative inside. In some cells the negative difference of potential appeared immediately on penetration. In others only the positive difference of potential was obtained, but in most of these the negative difference of potential appeared on a second penetration in a slightly different direction.

It would seem that the initial positive difference of potential exists between the cytoplasm and the external medium and that the negative difference of potential occurs on penetration of some internal structure of the cell.

Electron micrographs[2] show that the ascites tumour cell, the diameter of which is about 20–30μ, contains a very large nucleus, which may occupy up to half the volume of the cell and is often situated eccentrically; and that as the cells deteriorate they may develop vacuoles almost as large. However, with cells that were obviously deteriorating, the negative difference of potential was elicited much less frequently (although the positive could usually be obtained). Thus it is probable that the structure penetrated was the cell nucleus.

The positive internal potential of the cytoplasmic membrane could be explained, on the basis of the Goldman equation, if one assumes a high permeability to sodium compared with potassium[3]. It has been shown[4] that these cells have an abnormally high permeability to sodium.

I wish to thank Prof. F. H. Shaw for his encouragement and helpful advice during the course of this work.

B. M. JOHNSTONE*

Department of Pharmacology,
University of Melbourne,
Victoria. Oct. 14.

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* General Motors Holden Fellow.

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Differences between Self-Incompatibility and Self-Sterility

THE term 'self-sterile' is used for describing plants which fail to set self-seed when they are grown in isolation or when they are self-pollinated. Silow[1] reviewed the early usage of this term and proposed the term 'voluntarily self-sterile' to describe *Lotus* plants that fail to set seed when isolated from insects and 'artificially self-sterile' when they still fail to set self-seed following artificial self-pollination. He observed that several *Lotus* species in isolation set more self-seed following artificial self-pollination than the same plants without artificial self-pollination. This difference can be accounted for by the presence of a stigmatic membrane which prevents germination and growth of any pollen. This membrane is ruptured by artificial self-pollination or by insect pollination of the flower, after which pollen can germinate and grow. The presence of a stigmatic membrane was observed by Elliott[2] in *L. tenuis* and by Giles[3] in *L. corniculatus*. Giles[3] was unable to observe any difference in germination between self- and cross-pollen once the membrane ruptured. The presence of a similar membrane was observed by me[4] in several other *Lotus* species. This membrane can account for the observed voluntary self-sterility and for differences between voluntary and artificial self-sterility, but it does not account for artificial self-sterility.

Several mechanisms which can cause artificial self-sterility are known. One of these is genetic 'self-incompatibility', as was first described by East and Manglesdorf[5]. Another is 'somatoplastic sterility' which causes post-fertilization abortion, first described by Brink and Cooper[6]. Several other possible causes have been postulated. Mechanisms which involve post-fertilization abortion lead to destruction of individual ovules, whereas incompatibility saves the ovules for fertilization by any cross-pollen that may be present. Post-fertilization abortion may be suspected if all ovules do not form seeds following pollination by a mixture of cross- and self-pollen. However, variability in rate of ovule development within ovaries may be expressed in the same way, as discussed by me[4].

The terms 'self-incompatibility' and 'incompatibility' are used for describing certain genetic outbreeding mechanisms of a type first described by East and Manglesdorf[5]. Two main systems are found in angiosperms with homomorphic flowers. These systems are controlled by incompatibility alleles at one or two loci in which incompatibility is found between the alleles in the pollen grain and the flower pollinated (gametophytic) or between the alleles of the pollen parent and the flower pollinated (sporophytic). The actual systems found are listed by Pandey[7]. These systems act on the incompatible pollen by retarding or inhibiting growth of pollen tubes. If a mechanism is provided to ensure that cross- and self-pollen germinate on the stigma at the same time, retarded growth alone will provide an effective incompatibility mechanism. This is a function of the stigmatic membrane in *Lotus*.

From these definitions, it can be seen that a self-sterile plant species may possess a genetic self-incompatibility mechanism; but it does not follow that the self-incompatibility mechanism is the direct cause of self-sterility. Also, a voluntarily self-sterile species which possesses an effective self-incompatibility mechanism may be either artificially self-sterile, artificially self-fertile or intermediate between these two possible extremes.

Our work with *Lotus corniculatus* indicates the importance of recognizing that incompatibility and self-sterility may be separate phenomena with independent genetic mechanisms. The presence of an incompatibility mechanism is indicated by differential growth-rates of pollen tubes within the ovaries with self- and cross-pollinations, as reported by Giles[3]. Also, the good fits to hypothetical genetic ratios obtained by Dawson[8] would be unlikely if an incompatibility system were not present, as he did not practise emasculation. The presence of self-sterility is indicated by reduced pod and seed set from flowers that are isolated from insects or from flowers that are self-pollinated, which has been demonstrated repeatedly as reported by Silow[1]. Giles'[3] observation that self-pollen tubes reach the base of the ovary beyond the basal ovules, although more slowly than cross-pollen tubes, and his further observation that the relative growth-rate of cross- and self-pollen tubes are the same in relatively self-fertile and self-sterile plants, are an indication that self-incompatibility is not the cause of self-sterility in *Lotus corniculatus*. Giles[3] and I[4] observed evidence of post-fertilization abortion following selfing and I also noted that some aborting ovules exhibited characteristics of 'somatoplastic sterility'. This may account for the observed self-sterility. Therefore, self-incompatibility and self-sterility should be considered as separate phenomena in this species.

It follows that self-sterility and self-incompatibility in *L. corniculatus* may be controlled by separate genetic mechanisms. Observations were made on pod and seed set from various reciprocal test crosses, including 64 test backcrosses between progeny and each parent, 56 test backcrosses between backcross progeny and the recurrent and cross parents, 157 S_1 progeny and their parents and 30 S_1 siblings were test crossed in all combinations. Although there was considerable variability in seed and pod sets, it was not possible to fit these data to any one-locus gametophytic incompatibility hypothesis, even if allowance is made for possible tetrasomic inheritance. Pandey[7] pointed out that certain incompatibility systems are characteristic of families and that this system is the one characteristic of Leguminosae. With further analysis, it was not possible to fit the data obtained to any of the other incompatibility systems that were listed by Pandey[7]. The results on setting of seeds and pods can be fitted to a polygenic inheritance model, as would be expected if self-sterility is caused by loss of heterosis leading to somatoplastic sterility. It appears that the results obtained measure self-sterility and that no evidence on the genetics of self-incompatibility has been obtained. It is highly probable that independent genetic mechanisms control self-incompatibility and self-sterility in this species.

The concept that incompatibility that does not produce self-sterility may be effective in outbreeding was developed by Bateman[9]. In *Lotus corniculatus*, it should be possible to breed out self-sterility without weakening the self-incompatibility system. Then, if suitable inbred lines can be produced, it should be possible to produce hybrid seed commercially in isolated fields using insect pollinators. We would expect a high proportion of hybrid seed from every flower that is visited by an insect carrying a mixture of pollen. Bees could also be used for producing self-seed in other isolated fields since incompatibility does not cause self-sterility. Fields used for hybrid seed production could be seeded in alternate rows or with mixtures of self-seed. Since evidence of hybrid vigour in *L. corniculatus* has been obtained by Mr. N. C. Lawson at Macdonald College (unpublished work), this offers a promising approach to breeding this species. It would appear that a similar approach would be very promising in other legumes where it may be possible to separate self-incompatibility and self-sterility. For example, the breeding plan for *Medicago sativa* presented by Bolton[10] may be more practical if these considerations are applied in this instance.

These results will be published in detail elsewhere.

I wish to acknowledge the help given in discussion by Drs. H. A. Steppler, R. I. Brawn and W. F. Grant.

J. S. Bubar

Department of Agronomy,
Macdonald College,
McGill University,
Quebec.
Nov. 26.

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A Technique for the Sterile Culture of Roots

The experimental methods which have been employed for studies of metallic ion deficiency effects in plant and animal chromosomes have hitherto involved the entire organism[1,2], and consequently have been under conditions of only partial control. It seemed desirable to design a method by which control of cell nutrition could be more closely approached. The method was developed for use in investigations of the effects of metallic ion deficiencies or excesses on chromosome structure, but it is not limited to experiments of this type. The technique has a two-fold advantage. In addition to maintaining control of nutrition, it is possible to use clonal lines of tissue for cytological studies, since many lateral roots can be obtained from a single bean of *Vicia faba*, and these roots can be maintained in culture. Brown and Possingham[3] have used a root-culture technique for

Table 1

Compound	gm./l.	Percentage in solution	Stock solution (per cent)	Dilution for final solution (c.c.)
Glucose	20	2	none	none
$Ca(NO_3)_2.4H_2O$	0·236	0·0236	2·36	10/1,000
$MgSO_4.7H_2O$	0·036	0·0036	3·60	1/1,000
KNO_3	0·081	0·0081	0·81	10/1,000
NaCl or KCl	0·065	0·0065	0·65	10/1,000
KH_2PO_4	0·012	0·0012	0·12	10/1,000
$Fe_2(SO_4)_3$	0·002	0·0002	2·00	0·1/1,000
Trace elements	(mgm./l.)			
H_3BO_3	0·06	0·000006	0·06	0·1/1,000
$CuSO_4.5H_2O$	0·04	0·000004	0·04	0·1/1,000
$MnSO_4.4H_2O$	0·04	0·000004	0·04	0·1/1,000
$ZnSO_4.7H_2O$	0·04	0·000004	0·04	0·1/1,000
$NaMoO_4.2H_2O$	0·02	0·000002	0·02	0·1/1,000
$FeCl_3.6H_2O$	2·00	0·0002	0·20	1/1,000
Gibberellic acid	5·00	0·0005	0·50	1/1,000

Table 2

Vitamin	mgm./100 c.c.
Biotin	10
Choline chloride	10
Folic acid	10
Nicotinamide	10
Calcium pantothenate	10
Pyridoxal hydrochloride	10
Thiamine	10
Riboflavin	1
B_{12}	10

100 c.c. stock solution made alkaline with 1 *N* sodium hydroxide until vitamins completely dissolved. Dilute as 10 c.c. (stock solution) in 1,000 c.c. medium

investigations of the effect of iron in *Pisum*, but their method differs somewhat from that described here because of a difference in the handling of the organisms, and the purposes for which the roots were cultured were not entirely the same.

The medium used is a modification of that developed by Bonner and Addicott[4]. The trace elements in the medium follow those used by Brown and Possingham. Each component of the medium is made up as a concentrated stock solution (Table 1) which can be kept refrigerated or frozen, and is diluted into the final volume of medium each time fresh medium is prepared. The vitamin solution (Table 2) is prepared by filter-sterilization and kept frozen in small aliquots which are added to the medium after the latter has been autoclaved. The medium is placed in milk dilution bottles which can be fitted with a Cornwall syringe apparatus, and the bottles are sterilized at 20 lb. pressure at 121° F. for 20 min. Following sterilization, the medium can be stored under refrigeration until needed, at which time the sterile vitamin solution is added.

Seeds (*Vicia faba;* variety Seville Longpod: Carters Tested Seeds, Ltd., London) were chosen for their high percentage of germination and low frequency of spontaneous chromosomal aberrations. The seeds are sterilized by immersion for 30 min. in a saturated solution of calcium hypochlorite in which 3 gm. of wetting agent (for example, 'Dreft') per litre have been dissolved. Storage dishes containing pure silica sand (coarse grade, American graded sand) and distilled water are autoclaved. The beans are then partially embedded in the sand. 'Vermiculite' should be used in place of the sand if the beans are not to be grown deficient in metallic ions. The beans are allowed to grow at 20–25° C. for 7–10 days. The sand is kept very moist, but with little or no excess water. When lateral roots appear to be at least 2 cm. in length they are ready for excision and transfer to culture plates. The lateral roots can usually be seen along the bottom and sides of the storage dishes. *Allium cepa* seeds, variety Southport White Globe, Associated Seed Growers, New Haven, Conn., were also used. These are sterilized as described for *Vicia faba* and placed in sterile Petri plates on moist filter paper. The roots are ready for excision and transfer to culture plates after about 4–5 days, when they are 2–4 cm. in length.

A thin layer of 'Pyrex' glass wool is placed in a 5-cm. Petri dish and the plates are autoclaved. Filter paper or fine graded, pure silica sand can be used in place of the glass wool if deficiencies are not required. Sterile medium is dispensed into the Petri dishes by a Cornwall syringe in amounts of 2–2·5 ml./plate. The medium used at the beginning of culturing contains gibberellic acid. The amount of medium used is enough to wet the glass wool, sand, or filter paper thoroughly. Tips of the lateral roots of *Vicia faba* or primary roots of *Allium cepa* are cut to a length of 0·5–1·0 cm., and 4–5 tips are placed in each Petri dish. The roots are incubated at 20–25° C., and are kept moist, but not covered with the medium, as required during growth. Two days following root excision they are transferred to fresh medium in fresh dishes, the medium now lacking gibberellic acid. The latter is done since gibberellic acid tends to slow down growth following the initial elongation of the roots. The roots are kept moist as described, and transferred every 4–5 days to fresh medium. The standard Feulgen method is used for preparation of root tip smears.

This work was supported in part by the American Cancer Society, the National Science Foundation, and the U.S. Atomic Energy Commission.

N. S. Cohn
T. Merz*

Merganthaler Laboratory for Biology,
Johns Hopkins University,
Baltimore, Maryland.
Nov. 25.

* Post-doctoral Fellow of the National Institutes of Health.

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Response of Rice to Small Differences in Length of Day

THE natural annual variation in length of day in Malaya is from 41 min. in the north (lat. 6° N.) to 8 min. in the south (Singapore; lat. 1° 20′ N.). The monthly differences in length of day in the principal rice-growing areas lie between 1 and 3 min. It has been recognized in reports of rice sowing date experiments in Ceylon[1,2] in Indonesia[3] and in Japan[4], that observed differences in time of emergence and maturation of the ear are possibly due to these small monthly differences in length of day. It has also been suggested that a decreasing length of day will advance flowering while an increasing length of day will delay flowering of rice[3,5].

Monthly sowings of a Malayan rice, Siam 29—an *indica* variety of rice (*Oryza sativa*, L.), were carried out at Malacca (lat. 2° 12′ N.) and Kota Bahru (lat. 6° 09′ N.) and the results (Table 1) show considerable variation in the times to emergence of the ear for each sowing date.

These results, which are typical of a number of experiments carried out in Malaya[5,6] show that plants sown in north Malaya flower earlier than those sown in the south for any given sowing date. The differ-

Table 1. Time to Ear Emergence at Different Latitudes in Days

Place	Day-length				Month of sowing (all sowings on 1st of month)											
	Maximum*		Minimum*		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	hr.	min.	hr.	min.												
Malacca	12	14	12	00	329	311	—	232	214	199	187	168	161	172	—	205
Kota Bahru	12	28	11	47	266	276	272	217	202·5	174·5	153	141	128	127·5	135	138

* Maximum and minimum lengths of day occur during the summer and winter solstice respectively.

ences are almost certainly not due to responses to temperature for there is very little change in temperature with latitude or season in Malaya[5]. Since the rice variety used in these experiments does not become sensitive to length of day until it is 4 weeks old, the lengths of day effective for inducing flowering must occur some 4 weeks after planting. The number of inductive short days which can be utilized by the plant in the north are more than in the south. They are also shorter. As short-day plants react to the dark period rather than to the light period, dark induction of flowering takes place in a shorter time in north than in south Malaya. Such sowing date experiments therefore indicate the photo-inductive effect of length of day to be cumulative, and suggest that the daily changes which occur with increasing length of day do not delay flowering and that the daily changes with decreasing length of day do not advance flowering.

To test this hypothesis, duplicate plants of Siam 29 were sown in pots in Kuala Lumpur (lat. 3° 08′ N.) and given continuous treatment with lengths of day differing by 5 or 10 min. The required lengths of day of 11 hr. 40 min.; 11 hr. 50 min.; 11 hr. 55 min.; 12 hr.; 12 hr. 5 min.; 12 hr. 10 min.; and 12 hr. 20 min. were obtained by covering each individual plant with an opaque cylindrical cover. All covers were removed manually as rapidly as possible each morning, and were replaced at the required intervals each evening. All covers could be removed within 4 min. Thus the day-length error in any one treatment was in the region of 15–20 sec.

The results, which record the mean time to 50 per cent ear emergence and to harvest for the duplicates, are shown in Fig. 1. In spite of the technical difficulties involved, the curves obtained are reasonably smooth. The results for 11 hr. 30 min. length of day has been taken from another experiment[6] carried out on the same variety. These results show that the response of Siam 29 is directly related to the length of day. The longer the total amount of darkness (that is, the shorter the day) received during the period of sensitivity the more rapidly does the ear emerge.

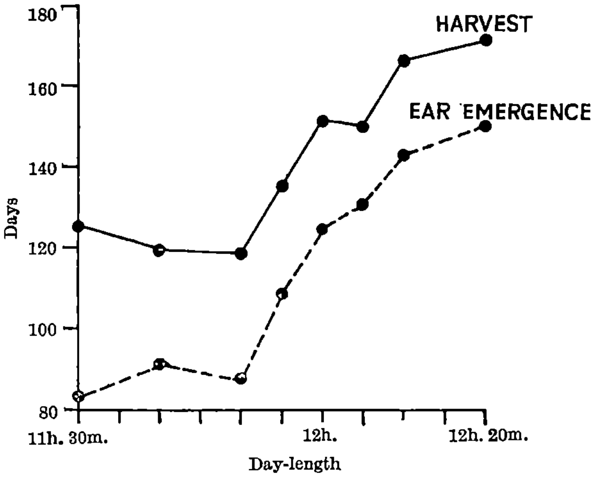

Fig. 1. Time to flowering and harvest in Siam 29

Chandraratna has produced curves of photosensitivity of a number of *indica* rice varieties, and these show that there are a minimum and a maximum length of day for effective flower stimulation. Rice is thus shown to be a short-day plant with a qualitative day-length response, which possesses no strongly defined critical day-length. Lang[8] has noted that plants with this type of behaviour cannot be fitted into the normal definitions of long- and short-day plants. Neither can their photosensitive behaviour be fully explained on the basis of the phasic and hormone theories of Gregory[9]; Hamner[10] and Lang[8]. The presence in such varieties of two limiting dark periods suggests that an internal mechanism of the diurnal type described by Bunning[11] provides a more satisfactory explanation for the behaviour of the plant to photoperiods of the order of 12 hr. If it is assumed that Siam 29 behaves in the same way as the varieties studied by Chandraratna[7] its response to very small differences is explainable, since the natural lengths of day found in Malaya and the lengths of day used in the experiment described here will fall in the steepest part of the photosensitivity curve characteristic of *indica* varieties of rice. Such lengths of day will also be of the same length as one of Bunning's[11] diurnal periods and will thus show the maximum inhibition of flowering, whereas plants receiving day-lengths less than 12 hr. will flower earlier because of the greater effectiveness of the light received during the middle of one of these periods.

It is hoped that further investigations of this phenomena will be made using a specially designed time-switch which can accurately control lengths of day to 1-min. intervals, and which is now available in this department.

I thank Mr. P. V. Thevan for technical assistance. This communication is published with the permission of the Director of Agriculture, Federation of Malaya.

J. Dore

Department of Agriculture,
Kuala Lumpur,
Malaya.

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A Method of growing Grass Plants with Separation of Seminal and Adventitious Roots

In the course of physiological investigations on grass roots it was necessary to grow plants of timothy (*Phleum pratense* L.) with their seminal and adventitious root systems separate from each other, so that different nutrients could be fed to each.

Although 'split root' techniques have been used in the past[1], no satisfactory method has been described. Timothy seedlings have a single, very thin seminal root easily killed by desiccation. Solutions can be supplied separately to seminal and adventitious roots, but tend to intermix as a result of capillarity or surface-tension effects. The following simple method of preventing this intermixture has been found to work well: plants have been grown to the flowering stage by this means.

Seeds are germinated on gauze ('Terylene' net, supported by a ring floating on dilute culture solution, has been found to be satisfactory). When the seminal root is 10–15 mm. long, but before adventitious roots appear, seedlings are transferred to containers constructed as shown, in vertical section, in Fig. 1. The pots are polystyrene containers now widely used for packing jam and other foods, and are obtainable in several colours or transparent and colourless. A glass tube is sealed by heat into a hole in the base of the inner pot, and passes through a larger hole in the base of the outer pot. Both pots contain dry 'Vermiculite', retained at the holes by glass wool. The polythene top of the inner pot has a short (3–4 cm.), fairly wide (4–5 mm.) glass tube sealed through it, and a small hole in the centre through which the seminal root of the seedling is threaded and afterwards sealed in, from the inside, with wax of low melting point (39° C.). This top, complete with seedling, is then fitted on the pot, and more 'Vermiculite' is added to the outer pot, covering the top of the inner one as deeply as possible without burying the seedling. The 'Vermiculite' is then soaked with water or culture solution, the glass tube in the lid of the inner pot being used for watering this pot. The lower tube prevents mixing of the drainage from the two pots: its end should be treated with wax or a silicone preparation to prevent liquid from creeping up it, or, alternatively, a length of flexible tubing may be attached to lead away the drainage.

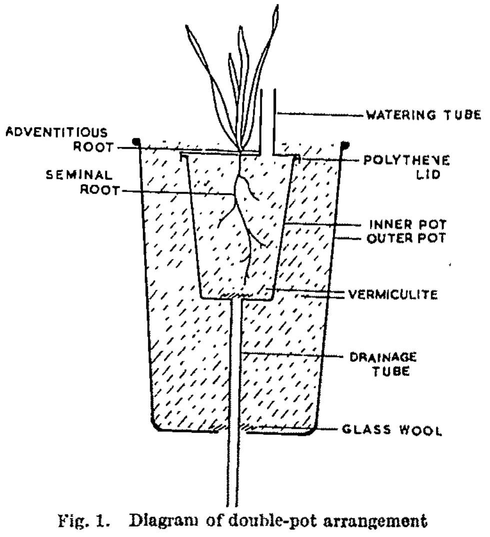

Fig. 1. Diagram of double-pot arrangement

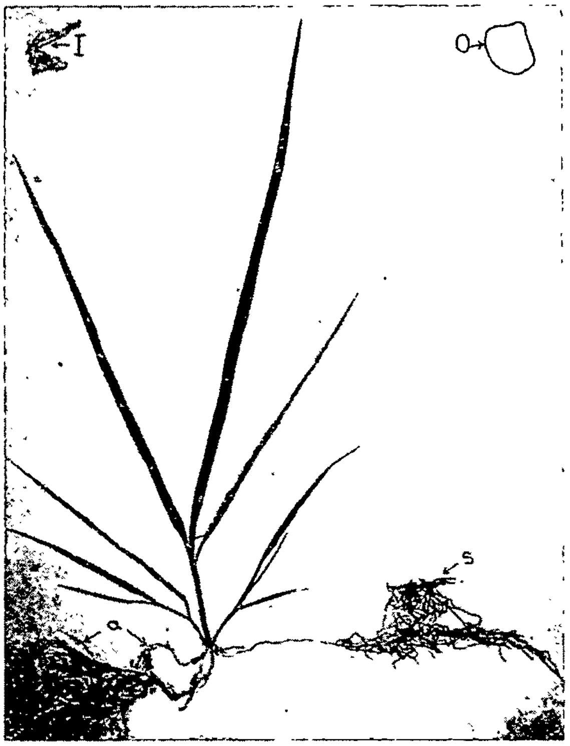

Fig. 2. Autoradiograph of a 5-week-old timothy plant. 5 μc. of sulphur-35 was given to the inner pot, and the plant was killed and exposed to X-ray film four days later. Film exposed for eight days. *s*, Seminal roots; *a*, adventitious roots; *I*, image given by 'Vermiculite' from the inner pot; *O*, position of 'Vermiculite' from outer pot

The pots used have capacities of 40–335 ml. However, a 335-ml. pot could conveniently be used as the inner one, with an ordinary plant pot as the outer; this would enable plants to be grown to a larger size before becoming 'pot-bound'.

A test was made to ensure that no transfer of solution took place between the two pots. 2 or 5 ml. of solution containing cæsium-137 were added to the inner or outer pots, respectively, of six containers in which there were growing seedlings. After a week, during which only enough culture solution was added each day to keep the 'Vermiculite' saturated, counts were made, with a scintillation counter and a ratemeter, of 'Vermiculite' from the untreated section of each container. The counts ranged from 2·9 to 3·3 per sec. (background count, 2·9) while a similar sample from a treated section gave a count of 60 per sec.

Experiments have since been carried out using sulphur-35 as a tracer. Autoradiographs were prepared of the 'Vermiculite' as well as of the plants. While in most cases the tracer has been found in both root systems, no matter to which it was directly supplied, 'Vermiculite' from the untreated pots has never given a positive autoradiograph, while that from treated pots has given a very clear image (Fig. 2). From this it is concluded that the sulphur-35 was translocated to the untreated root system through aerial parts of the plant, in which it was invariably found.

R. Dorrington Williams

Grassland Research Institute,
Hurley, Berks.
Nov. 25.

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[1] Hewitt, E. J., Tech. Comm. 22, Comm. Bur. Hort. Plantation Crops (1952).

A. or mμ in Electron Microscopy?

It has become customary to express measurements made by the electron microscope in A. units. I have analysed this custom by examination of Vol. 12 of *Experimental Cell Research* (1957). Nine of the papers are concerned with electron microscopy. A. units are mentioned twice in theoretical considerations concerned with the minimum determinable thickness of a layer of osmium, and they are also used as ordinates in graphs. These uses of the units are here disregarded, because they are not actual measurements. (The use of A. units in reports of X-ray analysis is also disregarded.) With these exceptions, I find 129 measurements recorded in A. units in reports of work in electron microscopy. The last digit of 117 of these is 0; of ten, 5; of two (both in the same paper), 7.

It is clear that the last digit is not significant, and indeed this follows from theoretical considerations. It would be unreasonable to express all measurements made with the light microscope in 'decimicrons', but a better case could be made for this than for the use of the angstrom as the standard unit in electron microscopy. Actually, we have just the right denomination for electron microscopy in the millimicron (mμ). If we used this unit (as a few authors do), the last digit would be significant (though the tissues of organisms would necessarily have changed in dimensions before being measured).

It is a remarkable fact, not recognized by the inventors of the metric system, that the human mind jumps naturally in thousands. Thus we write 2,654,396, not 2,65,43,96 or 265,4396. Similarly, no denominations between millimetre and micron have been found necessary. The decimetre is seldom used, and the centimetre only gained popularity because it was arbitrarily chosen as the unit of length in the C.G.S. system. The really useful measurements of length are the kilometre, metre, millimetre, and micron; and the millimicron is the logical continuation of the series.

JOHN R. BAKER

Department of Zoology,
University Museum,
Oxford.
Dec. 8.

Reorganization of Microbiological Research in Britain

I write to report the views of the Council of the Institute of Biology on the leading article in *Nature* of January 3 which dealt with the reorganization of industrial microbiological research in Britain. The article was informative but did not, it is felt, bring out the fundamental points at issue.

The proposals to strengthen microbiology in the stations of the Department of Scientific and Industrial Research concerned with particular technologies and to support fundamental microbiological research within university departments are in themselves admirable. But the most urgent need in industrial microbiological research is for work that bridges the gap between fundamental university research and its applications in diverse technologies. Such work, basic research undertaken with the needs of technology in mind, is carried out in other fields by the National Physical and National Chemical Laboratories within the Department of Scientific and Industrial Research and elsewhere by the stations and university research units controlled by the Medical and Agricultural Research Councils. The Microbiology Group at Teddington was the only group in Britain doing work of this character in industrial microbiology.

The Research Council of the Department of Scientific and Industrial Research has now abandoned responsibility for microbiological research of this character, despite the acknowledged success of the Teddington unit. Its decisions make no provision for a research unit on general industrial microbiology within the Department of Scientific and Industrial Research. It should be clearly understood that university units similar to the Medical or Agricultural Research Council's research units at universities are *not* contemplated and that the research grants to be made available to university departments will be of the same character as existed before these decisions were made.

All parties that have made representations against these decisions, including the late Advisory Committee on Microbiology, the Institution of Professional Civil Servants and ourselves, have emphasized that the research needed in this field is of a long-term character; sometimes, as with the methane-producing bacteria, very long term. It requires a research centre—a government laboratory or university unit of some size—which will provide a career for mature scientists experienced in the needs of technology as well as pure microbiology. Short-term grants to support postgraduate students on isolated projects in university departments will be totally inadequate, though they would be a valuable supplement to work of such a research centre.

What, in fact, will happen if the decisions of the Research Council of the Department of Scientific and Industrial Research are carried out? The present research group at Teddington—small but important because of its collective strength—will disappear, and in our view little if any of its work will be continued elsewhere in Great Britain. The real value of its work has been appreciated by British industry and by microbiologists all over the world. The National Collection of Industrial Bacteria, a world-famous collection of high repute, will be removed to the Torry Research Station in Aberdeen, which houses a collection of marine bacteria excellent in itself but comparable neither in scope, reputation nor size. The Research Council will have antagonized the whole world of microbiology, both by its decisions and by its cavalier treatment of the late Advisory Committee on Microbiology; one may well ask how the Department of Scientific and Industrial Research can expect in the foreseeable future to recruit any reputable microbiologists. The Corrosion Group at Teddington will be strengthened; a few university departments will receive grants for isolated items of research, but these could be made available in any event.

It is hoped that something can be done to establish a small national laboratory for industrial microbiology to continue the work which has been carried out by the Microbiology Group and to initiate new investigations likely to have significance for industrial processes. Is there not a case for an expert committee, nominated perhaps by the Royal Society, to advise the Research Council on this matter?

D. J. B. COPP
(General Secretary)

Institute of Biology,
41 Queen's Gate,
London, S.W.7.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 9

University College, Department of Biochemistry (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Prof. A. Haddow, F.R.S.: "The Chemistry and Biology of Cancer".* (Further lectures on February 16 and 23.)

British Society for the Philosophy of Science (previously Philosophy of Science Group) (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. P. G. 'Espinasse: "The Concept of the Gene".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Dissemination and Assimilation of Technical Literature" opened by Mr. J. K. Webb.

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. P. Ledoux (Université de Liège): "The Present State of the Stellar Stability Problem".*

Royal Aeronautical Society (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. E. G. C. Burt: "Theoretical Studies of Guided Missile Control Systems".

Tuesday, February 10

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. F. Parkinson: "Social Problems of Underdeveloped Countries".

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Dr. T. F. West: "The History of the African Pyrethrum Industry".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. P. Ledoux (Université de Liège): "The Secular Stability of Stars and Stellar Evolution".*

Society of Chemical Industry, Chemical Engineering Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. W. D. Jamrack, Mr. R. A. Wells and Dr. J. H. Buddery: "The Extraction of Thorium".

Royal Institute of Chemistry, London Section (joint meeting with the Sir John Cass College Chemical Society, at the Sir John Cass College, Jewry Street, London, E.C.3), at 6.30 p.m.—Dr. E. Lester Smith, F.R.S.: "Vitamin B_{12}—Recent Advances".

Wednesday, February 11

Physical Society, Low Temperature Group (at the Royal School of Mines, London, S.W.7), at 4 p.m.—Dr. T. J. Webber: "Some Problems in the Handling and Distribution of Liquefied Gases".

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. E. Prentice: "The Lower Culm Measures of the District South-West of Barnstaple, North Devon".

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. Behnke (University of Münster): "Modern Theory of Complex Functions of Several Variables. 1: The Notion of Complex Space".* (First of three Special University Lectures in Mathematics. Further lectures on February 12 and 13.)

College of Preceptors (in association with the School Nature Study Union, at 2 and 3 Bloomsbury Square, London, W.C.1), at 6 p.m.—Miss M. Hollings: "Should a Teacher of Natural History be Bound by a Syllabus ?"

Society of Instrument Technology, Data Processing Section (at Manson House, Portland Place, London, W.1) at 6 p.m.—Mr. L. Airey: "A Digital Instrumentation System for Use in the Testing of Jet Engines".

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. S. C. Britton and Mr. K. Bright: "Recent Research on the Corrosion of Tinplate".

Thursday, February 12

Institution of Chemical Engineers (at Church House, Westminster, London, S.W.1), at 9.30 a.m.—Symposium on "Mass Transfer".

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. A. Haddow, F.R.S.: "The Chester Beatty Research Institute".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. L. Monteith: "Micro-meteorology in Relation to Plant and Animal Life".

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. James Lawrie: "Reading about Science".

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. W. H. Stephens: "Earth Satellites".

Chemical Society (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. E. R. H. Jones, F.R.S.: "Polyacetylenes" (Pedler Lecture).

Friday, February 13

British Psychological Society, Occupational Psychology Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Dr. J. B. Parry: "The Place of Personality Appraisal in Occupational Selection" (Chairman's Address).

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Anniversary Meeting (followed by Annual General Meeting).—Dr. W. H. Steavenson: "The Instruments of Sir William Herschel" (Presidential Address).

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. F. K. Bannister: "Induction Ramming of Small High Speed Air Compressor".

British Institution of Radio Engineers, Medical Electronics Group (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. Peter Styles: "Some Instrumentation Problems in Medical Electronics with particular reference to Electromyography".

Antiquarian Horological Society (at the Science Museum, South Kensington, London, S.W.7), at 7 p.m.—Mr. F. H. Knowles Brown: Illustrated lecture on "The A. H. S. Tour in Switzerland, June 1957".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Harry Godwin, F.R.S.: "The History of the British Flora".

Saturday, February 14

Biochemical Society (in the Beveridge Hall of the Senate House, University of London, W.C.1), at 10.30 a.m.—Symposium on "The Biosynthesis and Secretion of Adrenocortical Steroids".

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Norman Cook: "Unearthing London".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Inspectors of Fisheries (5) (with a degree or equivalent in zoology, plus an adequate knowledge of botany) in the Department of Lands, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin, Ireland (February 13).

Technician (with workshop and preferably previous hospital experience) in the Physics Department—The Administrative Officer, Marie Curie Hospital, 66 Fitzjohn's Avenue, London, N.W.3 (February 13).

Biometrician in the Department of Research and Specialist Services—Ministry of Agriculture, Federation of Rhodesia and Nyasaland, for duties which will include the design of experiments in all phases of agriculture and animal husbandry research, together with the analysis of data and related statistical practice—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (February 14).

Lecturer or Assistant Lecturer in Mechanical Engineering—The Registrar, Manchester College of Science and Technology, Manchester 1 (February 14).

Assistant Lecturer (qualified in either pure or applied mathematics) in Mathematics—The Registrar, University College of North Staffordshire, Keele, Staffs (February 16).

Senior Lecturer (suitably qualified man or woman) in Radiochemistry at the College of Technology, Liverpool—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (February 20).

Leverhulme Research Fellows (2) in Radioastronomy—The Registrar, The University, Manchester 13 (February 21).

Assistant Lecturer (veterinary surgeon or with a degree in physiology) in the Department of Physiology—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1 (February 28).

Assistant (science graduate, preferably with qualifications in physiology) in Clinical Chemistry—The Secretary, The University, Aberdeen (February 28).

Fellow (preferably with a Ph.D. degree in physics or metallurgy or equivalent research experience in these fields) in Metal Physics, Division of Tribophysics, C.S.I.R.O., Melbourne, Australia, to study crystal defects and the mechanism of plastic deformation—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 370/123 (February 28).

Lecturer in the Department of Astronomy—The Secretary, The University, Edinburgh (February 28).

Imperial Chemical Industries Research Fellows in Chemistry, Biochemistry, Physics, Engineering, Chemotherapy and related subjects—The Secretary, Academic Council, The Queen's University, Belfast (March 1).

Principal—The Secretary, The Royal College of Science and Technology, George Street, Glasgow, C.1 (March 1).

Botanical Artist (Research Assistant II) (with a knowledge of plant form equivalent to that required at G.C.E. (Advanced Level) and preferably art training to the level of National Diploma in Design), to make plant models and illustrations—The Secretary, National Museum of Wales, Cardiff (March 6).

Research Fellow or Fellow in the Department of Statistics, Research School of Social Sciences, Australian National University, Canberra, for work in the field of mathematical statistics and its applications to other sciences—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 16).

Principal (with high academic qualifications and appropriate educational and administrative experience)—Clerk to the Governing Body, Northern Polytechnic, London, N.7 (March 31).

Assistant or Associate Professor (with an honours degree in mathematics and preferably some postgraduate experience in research or teaching) in the Department of Mathematics—Head of the Department of Mathematics, University of New Brunswick, Fredericton, N.B., Canada.

Assistant Statistician (with an honours degree in statistics, or in mathematics with a diploma in statistics, and desirous of working in the fields of biology or medicine) in the Medical Research Council's Pneumoconiosis Research Unit, Cardiff—The Director, Pneumoconiosis Research Unit, Llandough Hospital, near Penarth, Glamorgan.

Assistant Professor of Chemistry, to teach physical chemistry up to honours degree standard—The President, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

Freeland Chair of Chemistry—The Secretary, The Royal College of Science and Technology, Glasgow.

Geologist (with an honours degree in geology or equivalent qualification, special qualifications in ore mineralogy, and postgraduate experience in handling problems of ore genesis and ore microscopy), for duties chiefly concerned with laboratory work in Copenhagen, and also a certain amount of field work in Greenland—The Director of Survey, Grønlands Geologiske Undersøgelse, Østervoldgade 7, Copenhagen K., Denmark.

Head of the Department of Physics—Chairman of the Staff Committee, Essex College, Assumption University of Windsor, Windsor, Ontario, Canada.

Junior Scientific Officer (male or female, with an honours degree in science, pharmacy or biology), for duties consisting of technical work in the Blood Transfusion Service Laboratories—The Director, Blood Transfusion Service, Roby Street, Manchester 1.

Laboratory Technologist (male or female, A.I M.L.T., and preferably experience in serological techniques and tissue culture connected with virology) with the West African Council for Medical Research (Virus Research Unit, Yaba, Nigeria)—The Crown Agents, 4 Millbank, London, S.W.1, quoting Ref. M.3C/52407/NF.

Plant Physiologists (2) (with a good honours degree in botany or natural science with two years suitable postgraduate training or experience) at the West African Institute for Oil Palm Research, Nigeria; one to review present methods of production and initiate ways of increasing the supply of palm oil, and the other to carry out leaf analysis and other investigations into the nutrition of the oil palm—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/199/013.

Senior Lecturer (preferably with a higher degree in chemical engineering and several years teaching experience at university or technical college level) in Chemical Engineering at the University of Mandalay, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting A.12/BUR/TCS/217.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Southern Regional Council for Further Education. Eleventh Annual Report, October 1958. Pp. 36. (Reading: Southern Regional Council for Further Education, 1958.) [2611

Year Book of the Physical Society, 1958. Pp. v+106. (London: Physical Society, 1958.) 12*s*. 6*d*. [2611

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1958. No. 3: Modern Aspects of Thermochemistry. By Dr. H. A. Skinner. Pp. ii+52. (London: Royal Institute of Chemistry, 1958.) 6*s*. net. [2611

Ministry of Housing and Local Government. Local Government Finance (England and Wales). The General Grant Order 1958. Report by the Minister of Housing and Local Government under Section 1 (6) of the Local Government Act 1958. Pp. 10. (London: H.M. Stationery Office, 1958.) 9*d*. net. [2611

At the Farmer's Service: a Handy Reference to Various Services Available to Farmers in England and Wales. Pp. ii+68. (London: Ministry of Agriculture, Fisheries and Food, 1958.) [2711

Interdepartmental Committee on Social and Economic Research. Guides to Official Sources No. 1: Labour Statistics—Material collected by the Ministry of Labour and National Service. Pp. vii+78. Revised May, 1958. (London: H.M. Stationery Office, 1958.) 5*s*. net. [2711

General Register Office. Studies on Medical and Population Subjects No. 14: Morbidity Statistics from General Practice, Vol. 1 (General). By Dr. W. P. D. Logan and A. A. Cushion. Pp. iv+174. (London: H.M. Stationery Office, 1958.) 15*s*. 6*d*. net. [2711

B.B.C. Engineering Monograph No. 21: Two New B.B.C. Transparencies for Testing Television Camera Channels. By G. Hersee and J. R. T. Royle. Pp. 19. (London: British Broadcasting Corporation, 1958.) 5*s*. [2711

Commission for Technical Co-operation in Africa South of the Sahara—Scientific Council for Africa South of the Sahara. Conferencia Internacional dos Africanistas Ocidentais, Vol. 4: Zoologia e Biologia Animal. Pp. 264. (London: Joint Secretariat, C.C.T.A./C.S.A., 1956.) [2811

The Registrar General's Statistical Review of England and Wales for the year 1956. Part 3: Commentary. Pp. xvi+294. (London: H.M. Stationery Office, 1958.) 16*s*. 6*d*. net. [2811

Planning, Vol. 24, No. 428 (28 November 1958): The Development of the Steel Industry. Pp. 257–276. (London: Political and Economic Planning, 1958.) 2*s*. 6*d*. [2811

Boiler Availability Committee. Technical Paper No. 4: Improved Methods of Analysis of Coal Ash, Slag and Boiler Deposits. Pp. 30. (London: Boiler Availability Committee, 1958.) [2811

Ministry of Housing and Local Government. Local Government Finance (England and Wales). The General Grant Order, 1958. Supplement to the Report by the Minister of Housing and Local Government under Section I (6) of the Local Government Act, 1958. Pp. 12. (London: H.M. Stationery Office, 1958.) 9*d*. net. [2811

Ministry of Pensions and National Insurance. Digest of Statistics Analysing Certificates on Incapacity, 1955–56. Pp. 27+71 tables +1 chart. (London: Ministry of Pensions and National Insurance, 1958.) [2811

Other Countries

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 39, (October, 1958): Rise in Hospital Admissions. The Population of Alaska. Blindness in the United States. Fatal Accidents in Large Cities. Pp. 12. (New York: Metropolitan Life Insurance Company, 1958.) [2511

Analele Stiintifice ale Universitătii "Al. I. Cuza" din Iasi. (Series Nouă.) Sectiunea 1: (Matematica, Fizică, Chimie.) Tomul III, Anul 1957, Fasc. 1–2. Pp. viii+480. (Iasi: Universitătii "Al. I. Cuza", 1957.) [2511

Annals of the New York Academy of Sciences. Vol. 73, Article 5: Psoriasis. By Peter Flesch and 12 other authors. Pp. 911–1037. Vol. 74, Article 2: Photoreception. By Jerome J. Wolken and 32 other authors. Pp. 161–406. (New York: New York Academy of Sciences, 1958.) [2511

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 39, No. 20: Marine Mollusks from Bougainville and Florida, Solomon Islands. By Alan Solem. Pp. 213–226. 30 cents. Vol. 3, No. 21: The Crocodilian Genus *Paleosichus*. By Frederick J. Medem. Pp. 227–247. 50 cents. Vol. 39, No. 22: A New Genus and Species of Fish from the Gulf of Mexico (Family Emmelichthyidae). By Loren P. Woods. Pp. 249–252. Vol. 39, No. 23: A Note on the Philippine Frogs related to *Rana macrodon*. By Robert F. Inger. Pp. 253–255. 10 cents. Vol. 42, Pp. 6: Philippine Zoological Expedition, 1946–1957. Stoneflies from the Philippines (Plecoptera). By Stanley G. Jewett, Jr. Pp. 77–87. 40 cents. (Chicago: Chicago Natural History Museum, 1958.) [2511

Indian Central Cotton Committee: Technological Laboratory. Technological Bulletin, Series A, No. 95: Technological Reports on Standard Indian Cottons, 1957. By Dr. R. L. N. Iyengar. Pp. ii+112. (Bombay: Indian Central Cotton Committee, 1958.) Rs. 2.00. [2611

Sveriges Geologiska Undersökning. Ser. Ca, Nr. 41: Beskrivning till Berggrundskarta över Urberget I Norrbottens Lan. Av Olof H. Ödman. Pp. 151 med 4 specialkartor. Karta och beskrivning 65 kronor. Karta 45 kronor. Ser. Ba, Nr. 17: Beskrivning till Jordartskarta över Sverige. Av G. Lundqvist. Med en karts i tre blad. Pp. 106. 5 kronor. Karta per blad 14 kronor. Ser. C, No. 553: Göteborgstraktens Berggrund. Av P. H. Lundegardh. Pp. 82+1 plate. 7.50 kronor. Årsberättelse för År 1957. Pp. 21. 0.50 kronor. (Stockholm: Sveriges Geologiska Undersökning, 1957 and 1958.) [2711

Central Building Research Institute, Roorkee, India. Annual Report, 1957–58. Pp. ii+32. (Roorkee, U.P.: Central Building Research Institute, 1958.) [2711

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United States Department of Agriculture. Agriculture Handbook No. 154: Insecticides from Plants—a Review of the Literature; 1941–1953. By Martin Jacobson. Pp. iv+299. (Washington, D.C.: Government Printing Office, 1958.) [2811

Food and Agriculture Organization of the United Nations. Report on the 1950 World Census of Agriculture, Vol. 2: Census Methodology. Pp. ix+168. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1958.) 10*s*.; 2 dollars. [2811

Thirteenth Annual Report of the Council of the Queensland Institute of Medical Research for the year ended 30th June, 1958. Pp. 21. (Brisbane: Queensland Institute of Medical Research, 1958.) [1612

Federation of Malaya. Annual Report of the Department of Agriculture for the year 1956. By R. G. Heath. Pp. vii+115+5 plates. (Kuala Lumpur: Government Printer, 1958.) 2.50 Malaya dollars. [1612

Bulletin of the American Museum of Natural History. Vol. 116, Article 2: A Historical Review of the Mollusks of Linnaeus. Part 6: The Genus *Trochus* of the Class Gastropoda. By Henry Dodge. Pp. 153–224. (New York: American Museum of Natural History, 1958.) 1 dollar. [1612

Smithsonian Miscellaneous Collections. Vol. 138, No. 2: Evolution of Arthropod Mechanisms. By R. E. Snodgrass. Pp. iii+77. (Publication 4347.) (Washington, D.C.: Smithsonian Institution, 1958.) [1612

United States Department of Agriculture. Miscellaneous Publication No. 770: Locust and other Insect Control in Technical Co-operation Programs in the Near East, South Asia, and Africa, 1951–57—A Report of the Regional Insect Control Project. Pp. ii+147. (Washington, D.C.: Government Printing Office, 1958.) 70 cents. [1612

Transvaal Museum, Pretoria. Report for the year ending 31st March, 1958. Pp. 48. (Pretoria: Transvaal Museum, 1958.) [1612

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Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance,
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NATURE

No. 4659 SATURDAY, FEBRUARY 14, 1959 Vol. 183

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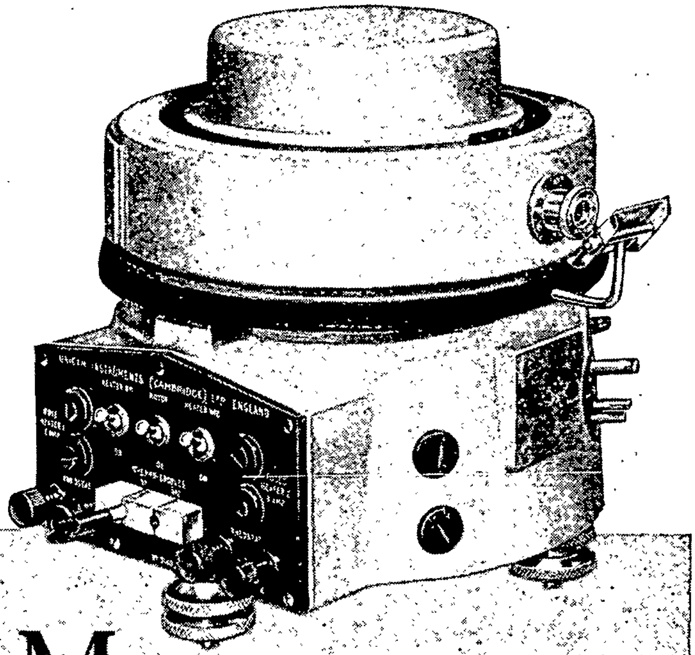

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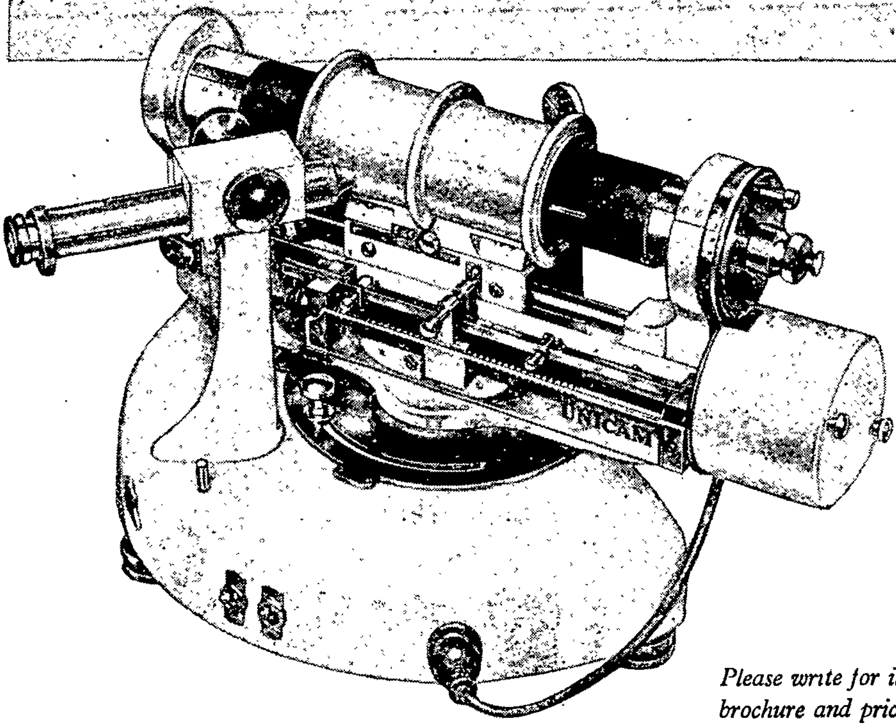

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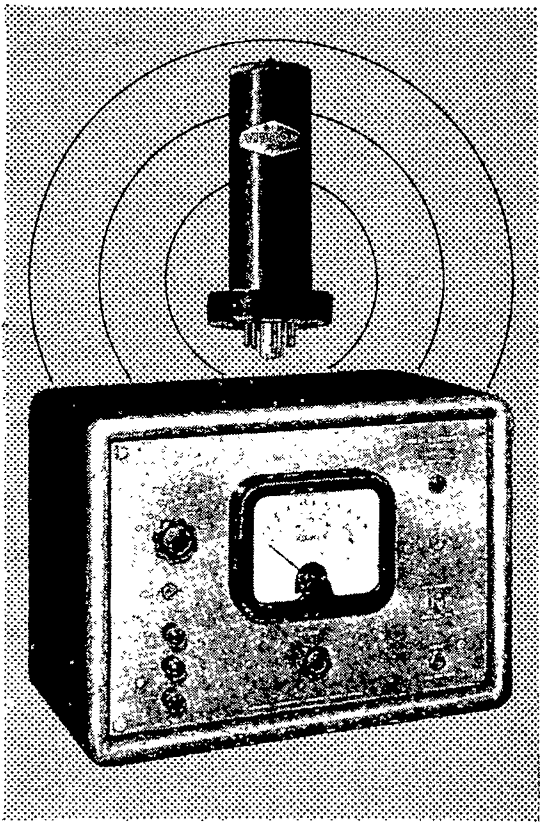

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ART AND SCIENCE OF MANAGEMENT

At a conference recently organized by the National Institute of Psychology, some ex-Service officers described their attempts to obtain posts in industry and commerce and their subsequent experiences. What surprised them most was the oft-repeated statement that, to be successful in industry, they would first have to unlearn all that they had ever been taught in the Services. Yet, by common consent, the qualities which would enable them to make headway were those that had become part and parcel of their behaviour because of the training they had received in the Forces. The systematic approach to a job, the discarding of the irrelevant and concentration upon the essentials became second nature to men who were steeped in the Service way of life. It is not surprising that these qualities are proving successful in civilian life and that, in the main, officers declared redundant by the Government's changed defence policy are not finding it particularly difficult to obtain suitable openings. These openings, however, are mainly in those companies which already have a proved record of success and are outstanding in their particular fields of activity. They are companies which have systematically developed the right kind of administration pattern to suit their organizations and have selected and developed their executive staff along equally systematic lines. These companies, unfortunately, are but a small proportion of those in British industry as a whole, and, by contrast, give prominence to many present defects and deficiencies.

Since the War the defects and deficiencies have been largely hidden by the boom period which has been called the seller's market. Now that products have to be sold as well as made, industry is becoming more and more aware that its greatest lack is of executive staff with qualities fitted to meet a challenge with which it has not hitherto been confronted. Despite the attention paid to executive development since the War, the large majority of managers in British industry are still men who have succeeded to their posts by their ability to stay in one position longer than other candidates; they have outlived their competitors. Despite the mildness of the present recession, many of them are bewildered by the too rapidly changing conditions, and lack the flexibility to overcome them.

By and large, these managers entered industry in days when the more intelligent and better-educated members of the community chose their careers among the professions. Many of the older managers were recruited from 'black-coated' workers and, as David Lockwood has pointed out*, obtained managerial positions by dint of their proximity to the employer, their superior literacy compared with manual workers, their knowledge of the firm's secrets and its financial affairs, and the tradition which decreed that office workers were more capable of running the business than men drawn from the shop floor. With the relative decline in status and prestige of the clerk, due to the spread of literacy among all sections of the community, as well as the long-overdue recognition of the place of the technologist and technician in industry, it is unlikely that the managers of the future will be drawn from the same sources as hitherto or trained in the same way. They will, in the main, come from the universities and the senior technical colleges, and their training will be consciously organized and much more concentrated.

How they are to be trained is a matter of considerable conjecture, and no fixed rules are likely to be prescribed. The traditional British dislike of 'theory' and strong preference for practical problems, the prejudices of many responsible business leaders who reached their positions 'the hard way' and believe that there can be no other, the fear that young men who study the art and science of management may become over-impressed with their own theoretical knowledge and ignore the wide variations in human behaviour, all [tend to preserve the *status quo*.

Of those who believe that management has developed a body of knowledge which can be taught and at a comparatively early age, probably the most able British advocate is Lyndall F. Urwick, chairman of Urwick, Orr and Partners, Ltd. In a privately published pamphlet*, Urwick argues that, in sharp contrast to its regard for the 'practical', the main opposition to the more formal teaching of management in Britain springs from our regard for the amateur. "Being a Director—and 'Director' is as yet the only title carrying social prestige which business and the outside world has recognized—is still, in part, a stronghold of the amateur. Many men are made directors of companies who have neither worked their way up through the ranks of management nor have qualified themselves professionally in other ways, . . . that they have any knowledge of the art and science of management or of the technique of the particular industry or trade with which the Company is concerned, they would be the last people to pretend." Having achieved control of a business through family or social connexions, they look askance at those who suggest that future directors and managers shall have professional qualifications and some knowledge of the art and science of management.

---

* "The Black-coated Worker" (Allen and Unwin, 1958).

* "Is Management a Profession?" (Urwick, Orr and Partners, Ltd., 29 Hertford Street, London, W.1, 1958).

Despite all the opposition engendered by custom, fear and prejudice, however, Urwick's views are increasingly finding support in British industry and commerce. Instead of learning the skills of management pragmatically over a long period of years, it is becoming clear that the Americans are not wholly wrong, and that there is a body of knowledge which can be taught, as is being done so successfully throughout the United States to-day. It is also becoming recognized that merely to provide short courses for older men is unsatisfactory and inadequate; many of the men who have attended such courses have been unable to profit by them and, as subsequent experience has shown, have returned to their companies with a surface accretion of knowledge which their set ways have made them unable to assimilate. There is a body of knowledge which must be taught when a potential manager is in his formative years. Some can be taught as part of his initial degree courses; much would better wait until he has had a few years doing a management job.

This does not mean that senior managers of the future will be selected for their 'knowledge about' management. In Urwick's own words, "Management is primarily a question of leadership. And leadership, while it can be refined and improved by experience under wise guidance, depends ultimately on the possession of certain qualities of character . . . all responsible people who advocate that management should become a profession are clear that practical experience is the most important element in the development of professional competence. Practical arts cannot be learned from books or lectures. They can only be learned by practice, by knowledge of and acquaintance with the occupation".

What systematic study can do is to make the process of 'learning by experience' more fruitful and more effective. Through books a young student of management can be made more reflective about his experience, can grasp more quickly and clearly what is happening around about him in factory and office. Books and study also help to systematize his experience, to make him more aware of what is lacking and enable him to fill the gaps. By referring the petty details of his early work as a junior to general principles, learning by routine becomes less uninteresting. In this way the well-founded training by apprenticeship will be strengthened when it is made more systematic and supported by theoretical requirements.

Unless the existing methods of training managers by learning on the job is supplemented by a considerable extension of theoretical studies provided by universities and senior technical colleges, British industry is unlikely to meet successfully the challenge before it. The greatest obstacle to progress in British industry is still a body of management which bases its thoughts and actions on traditional practices inherited from its predecessors. Rule-of-thumb must give way to an approach based upon scientific method and, in the present state of British industry, since this is unlikely to be caught, it must be taught.

MARINE ECOLOGY

Marine Ecology

By Prof. Hilary B. Moore. Pp. xi+493. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 76*s*. net.

THERE has long been need for just such a book as this and which Prof. Hilary Moore is admirably fitted to write. His experience ranges in latitude from Millport by way of Port Erin, Plymouth and Bermuda to Miami and so also covers both shores of the North Atlantic. His research has been equally wide, from his illuminating early studies on intertidal barnacles, dog-whelks and sea urchins, to examination of bottom deposits and of the deep scattering layer. Further, he writes with commendable clarity.

His book is well arranged, leading from description of environmental factors, physical, chemical and biological, to a consideration of habitats, from the abyss to the surface, while the second half of the book is devoted to the organisms which inhabit these environments and are controlled in distribution by these factors. The reader cannot but be impressed, and if he is himself a worker in this general field perhaps a little depressed, by the wealth of information now flooding in from autecologists and synecologists, from physical and chemical oceanographers, from fisheries biologists and statisticians, all of which must in some manner be synthesized. Indeed this is the concluding note of the book, the need for more reviewing and co-ordination of existing information.

Inevitably such a book, even running as this one does to 420 pages of text apart from appendix, references and index, represents the result of selection, and many may feel that more attention should have been paid to matters of particular interest to themselves. Certainly the list of references, though running to twenty-seven pages, is very far from complete. But Prof. Moore would not claim that it was or could be. I feel that more might reasonably have been made of estuarine conditions, including regions of low salinity like the Baltic and Caspian Seas, and especially regret there is no mention of the unique environment and population of mangrove swamps. But it is gratifying that adequate attention is paid to the biological, as distinct from the geographical, aspect of coral reefs.

Among the major impressions which emerge is the realization of how often, in the plankton, on the bottom, on the shore and in the mixed salinities of estuarine waters, it is the organisms themselves which represent the best criteria of environmental conditions. As Prof. Moore points out, the precise nature of the significant environmental factor or complex of such factors often either eludes the observer or else defies adequate measurement.

The wealth of information to be digested in preparing this book doubtless explains why it is a little out of date; there are few references much after 1950. Certainly an author must know when to stop, but it is a pity that more of the recent work on barnacles, where Prof. Moore was so notable a pioneer, has not been included, and there is no mention in the sections dealing with vertical migration of plankton of the highly significant work of Prof. J. E. Harris. But careful reading reveals few errors, although the influence of copper on settlement of oyster larvæ mentioned on p. 95 is surely no longer accepted and there appears to be a misreference to the subject-matter of Table 9–2 on p. 311. Misprints are commendably few in an extremely well-produced and fully illustrated book which does credit to both author and publisher. The sole drawback is the price, which it is hoped will prevent no institution from adding this book to its library. Marine biologists in general should buy it if they can, but in any event should most certainly read it. C. M. YONGE

GEOGRAPHICAL CLIMATOLOGY

The Climate of New Zealand

A Geographic Survey. By B. J. Garnier. Pp. 191+12 plates. (London: Edward Arnold (Publishers), Ltd., 1958.) 70*s*. net.

THIS superbly produced and distinctly expensive account of the principal features of the climate of New Zealand is derived in the main from numerous papers in scientific journals. Prof. B. J. Garnier, formerly of Otago and now at Ibadan, asks his readers to regard the volume primarily as an exposition of an important aspect of the country's geography and secondarily as an attempt to show how studies in systematic geography may make their particular contribution to the field of learning.

Like many geographers, he is evidently rather conscious of his subject and the occasional lapses into the jargon of geography are tiresome. "The overall climatic picture of eastern North Island is one in which some diversity is held together in a framework of common distinguishing elements . . . a remarkable quality of the area as a geographic entity is the way this pattern is repeated by other features" (p. 107) will be well understood by students who have been subjected to this sort of thing, but if they want to know about the climate they may still refer with profit to Kidson's ten beautifully concise pages in *The Quarterly Journal of The Royal Meteorological Society* for 1937. Phrases such as "As its name implies, northern New Zealand is the most northerly of the climatic regions" (p. 71); an "influx of influences" (p. 142) are infelicitous. Fortunately, like the southerly rainstorms, these affectations do not last long. There are many agreeable descriptive passages, and in a work on climate the many references to the physical background and the regional characteristics of the vegetation and soil are most welcome; for example, the admirable paragraphs of plant geography on p. 130. The illustration of a summer cold wave is excellent (pp. 118–9).

Beginning with a broad survey of New Zealand's climatic qualities and a discussion of how these have been produced by the combined effect of its position and physiography, the author then defines his climatic regions and in nine chapters discusses their characteristics. The splendidly chosen landscape photographs are a most attractive feature; maps and diagrams abound; synoptic situations and monthly sequences of daily maxima and minima are well displayed; there are useful tables, an extensive bibliography and an index. With its fine assemblage of references, this work is perhaps to be regarded as a regional geography rather than a text on climate; for the present reviewer could find no information about the absolute extremes of temperature, no clear definition of the snow-line, no comment about the marginal qualities of Mt. Egmont, nothing on the climate of Stewart Island; no comment on the astonishing freedom from screen frost at Wellington (p. 170) which, incidentally, makes the averages on p. 169 look a little odd. For the British reader there is no clear indication of how often snow either falls or lies; no map locating the stations; no detail about the frequency of thunderstorms. To say that conditions of permanent frost prevail on the high summits in North Island (p. 126) begs the question. Estimated lapse-rates of temperature in Appendix *A* are not related to upper-air data; and we hear nothing about the extent, if any, of climatic fluctuation in recent times. Rainfall reliability and also evapo-transpiration, a concern of many geographers, receive useful notice. To the regional geographer studying New Zealand as a whole this book, with its abundance of references, extracts, tables and maps, will have many virtues. It is costly, but can be a useful and indeed desirable acquisition to a library.

GORDON MANLEY

TROUBLED WATERS

An Introduction to Fluid Dynamics

By Dr. F. J. Bayley. Pp. viii+215. (London: George Allen and Unwin, Ltd., 1958.) 28*s*. net.

An Introduction to Fluid Dynamics

By Prof. G. Temple. Pp. xi+195. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 25*s*. net.

Proceedings of the Fifth Midwestern Conference on Fluid Mechanics

Held at the University of Michigan, April 1 and 2, 1957. Edited by Prof. A. M. Kuethe. Pp. viii+388. (Ann Arbor, Michigan: University of Michigan Press, 1957. Published for The Engineering Research Institute, Ann Arbor.) 8 dollars.

THE three volumes under review cater for different sections of the scientific community. Dr. Bayley aims at helping undergraduates in the engineering faculties while Prof. Temple's work is intended primarily for students reading honours mathematics or physics. The proceedings of the Fifth Midwestern Conference on Fluid Mechanics will appeal mainly to the research worker.

The introduction to fluid mechanics provided by Dr. Bayley is unsatisfactory. He has tried to write a simple book covering a wide field. This is extremely difficult to do, especially in two hundred pages, for it demands terse, lucid instruction. Unfortunately in this book the insistence on brevity has led to many vague statements and errors of omission. For example, the paragraph on units will do more to confuse than illuminate the situation. Such a text should surely start with a clear explanation of the three systems of engineering units in current usage and the relations between them. The chapter on fluids at rest contains no mention of floating bodies, and the presentation of the immensely powerful momentum equation is quite inadequate. Moreover, the compressible form of Bernoulli's equation is derived using $p = k\rho^{\gamma}$. This can easily lead students to believe that the equation holds only for this type of flow. Later in the book Dr. Bayley does present the general energy equation both simply and accurately.

Dimensional analysis receives the prominence it deserves and the principle is demonstrated in a number of well-chosen examples. The most successful chapters deal with pipe flow, channel flow and fluid machinery, but the discussion of flow over immersed bodies is poor. The role of viscosity in the production of lift and drag and the concepts of circulation and an ideal fluid are not clearly explained. It would have been better to have left these tasks to a more specialized text.

The book is attractively presented but some diagrams need alteration; for example, Fig. 9.5 purports to show the pressure distribution around an aerofoil section. There is no scale and in fact the body is an airship hull. There are a few references but no bibliography.

In contrast, the book with the identical title by Prof. Temple is rigorous in treatment and narrow in scope. He says in the preface that "the emphasis in fluid dynamics is no longer on analytical solutions of ingenious problems but on the development of the physical significance of the fundamental principles". Yet his book is not only limited to the theoretical aspect of fluid dynamics but also to the treatment of a perfect fluid deprived of viscosity and compressibility. As an introduction to fluid flow for mathematicians and physicists this is too severe a restriction. Viscosity and compressibility are the two most important properties that a fluid possesses. Unless their importance is realized and used as a guide to useful mathematical solutions, wholly misleading flow patterns based on the ideal fluid concept can result. Prof. Temple could avoid much criticism by re-naming the book "a monograph on the ideal fluid".

After deriving the momentum and energy equations a chapter is devoted to applications of Bernoulli's theorem. The compressible form of this theorem is again derived using "the adiabatic law $p \propto \rho^{\gamma}$", a doubly misleading treatment and the sole mention of compressibility. The existence of a velocity potential is rigorously established, then the method of building potential flows is explained and demonstrated by numerous examples. Among these is the circular cylinder with Thwaites flap. Here the connexion between theory and the behaviour of a real viscous fluid is clearly stated; moreover, the reference to the original work is given. Conformal mapping is used to find the continuous flow around the flat plate, circular arc and usual Joukowski profiles. This is followed by a section on discontinuous flow where the Helmholtz patterns are contrasted with the continuous flow results and the lifts and drags compared. One looks in vain, however, for the vital experimental evidence. The short last chapter is on incompressible slender body theory, the accuracy of which is well illustrated by comparison with the exact potential flow solution for the flow around an ellipsoid.

The whole book is well provided with references and there is a valuable bibliography to which the reader must refer for a more complete and clear picture of fluid dynamics.

Nowadays nearly every conference eventually publishes the papers presented in book form. The Fifth Midwestern Conference on Fluid Mechanics held at the University of Michigan on April 1 and 2, 1957, is no exception. This volume contains twenty-six of the original thirty-two papers.

Since they are nearly all of a specialized nature but on widely different aspects of fluid mechanics this method of presentation seems unwise. Few individuals will relish paying eight dollars for a collection of short reports, only a few of which are of immediate interest to them. Perhaps the book is aimed just at the libraries.

There are, of course, many interesting papers in the eleven sub-sections: stability of flows (3 papers), laminar flow (2), turbulent flow (6), supersonics (2), hypersonics (3), magneto-gasdynamics (1), gas jets in liquids (1), slider bearings (1), free surface (3), marine applications (2) and general (2). Among the authors are Henry Görtler, Lester Lees, Max Munk and S. I. Pai. All the papers are necessarily brief but include an abstract, introduction, brief description and conclusions. All are well provided with references and clearly set out. The figures are first-rate and the whole book beautifully photolithoprinted. The greatest criticism is that no discussion is included. Often at a conference the papers presented provoke important comment and bring to light additional information. All this is lacking, and one is left with the feeling that there must be a better way of distributing conference data to a wider public. J. L. STOLLERY

MORE PROGRESS IN NUCLEAR ENERGY

Progress in Nuclear Energy

Series 1: Physics and Mathematics, Vol. 2. Edited by D. J. Hughes, J. E. Sanders and J. Horowitz. Pp. vii+375. (London and New York: Pergamon Press, 1958.) 90*s.* net.

FAIRLY soon after the first Geneva Conference on the Peaceful Uses of Atomic Energy there was a spate of books and journals containing, so the publishers said, carefully written reviews of the vast amount of information released at that momentous meeting. In some cases the claim was justified; in others the publications were merely collections of the actual Geneva Papers with precious little editorial comment, and it is to be hoped that this sort of thing will not happen after the recent second Conference.

The first volume in Series 1 (Physics and Mathematics) of "Progress in Nuclear Energy" was, by and large, to be included in the first group and fully justified the publisher's claims. It had some very useful survey articles, particularly, one remembers, on the properties of fissile material.

The second volume in the series has now appeared and is well up to the standard of the first. The articles are again detailed and quite hard going even for the specialist reader. Allen and Henkel open this new collection with an article on the interaction of fast neutrons with thorium, uranium and plutonium. The behaviour of low-energy neutrons with various heavy nuclei is covered by Harvey and Schwartz, and these first two articles continue the useful collection, started in Vol. 1, of the data on cross-sections which are relevant to reactor design.

In reactor physics there is little point in having extensive data on neutron cross-sections unless information is available also on the energy spectra of neutrons in reactors. Precise measurement and calculation of these are difficult, but are being tackled in several laboratories, and the article by Poole, Nelkin and Stone on the "Measurement and Theory of Reactor Spectra" is very opportune.

Until quite recently there have been large discrepancies between the nominal values of the standard neutron sources used in different countries. However, a little international co-operation seems to have improved the position and there is now agreement in most cases to about 1 per cent. The present situation is reviewed by Richmond in an article which gives information also on the procedures used for calibration. Sources used as standards are usually based on alpha or gamma emitters, although spontaneous fission sources are now being tried.

For studies in neutron physics, sources using particle accelerators are very valuable, particularly as they can be pulsed. The use of pulsed sources in measurements on neutron diffusion is discussed by von Dardel and Sjöstrand in the fifth chapter of this new volume.

The last three chapters are concerned almost exclusively with theoretical aspects. The penultimate chapter, by Hassitt, is on the methods of calculation for heterogeneous reactors, and preceding it is a long discussion of the special problem of resonance escape probability. As the editors state in their preface, the methods of calculation take advantage of developments in computers and this is very evident in the final chapter on "Monte Carlo Methods in Transport Problems".

Altogether this is a nicely balanced collection of valuable articles. J. Walker

THE GREEN FLASH

The Green Flash and Other Low Sun Phenomena

By D. J. K. O'Connell, *S.J.* Photographs by C. Treusch, *S.J.* Pp. 192 (24 plates). (Castel Gandolfo: Specola Vaticana, 1958. Distributed by North Holland Publishing Company, Amsterdam; and Interscience Publishers, Inc., New York.) 45*s.*

The Sun, when close to the horizon before setting, may appear oddly distorted in shape, its upper rim showing traces of green colour while its lower portion is red. As the last segment of the upper rim approaches the horizon, pronounced green coloration may spread from its edges to fill the segment for the few seconds before it vanishes below the horizon. Much more rarely, at the instant when the last segment disappears below the horizon, a green flash may be observed to dart upwards at the point of disappearance. This is not an after-image, the green complementary colour subjectively following the sudden removal of the normal red at sunset, for it may be observed also at sunrise. It occurs when refraction in the atmosphere close to the Earth's surface is abnormally great, that is, when the density decreases rapidly with height. If Rayleigh scattering removes light of shorter wavelength than the green and absorption by water vapour and oxygen is effective in the orange and yellow, then the remaining colours red and green will be so separated by the abnormal refraction that the green will persist for a short period after the red has gone and the transition will be abrupt.

The Vatican Observatory, situated in the Alban Hills at a height of 450 m. with a western horizon at a distance of 80 km. over the Mediterranean, is well situated for a study of these phenomena. The many fine plates in colour and in black-and-white that appear in this volume show how successfully the very difficult tasks of photographing these evanescent effects and of reproducing them here in colour have been achieved. The techniques that were developed in using the Observatory telescopes are fully described, and detailed notes of description and analysis accompany each photograph along with meteorological and other relevant data. There are also some photographs of the green flash at sunrise over land, of the green rim of the setting Moon and of Venus and of experiments with artificial sunsets and layers of discontinuity.

While the author states that the main purpose of the book is "to provide observational material rather than to discuss the various phenomena exhaustively", he provides an interesting account of the history of this subject—it is surprising to learn that the earliest recorded observation of the flash that he deems authentic was made in 1865—a lucid, though brief, account of the theory with an examination of the factors that influence the characteristics of the phenomenon, and a comprehensive bibliography.

James Paton

ECOLOGY AND ECONOMICS OF AGRICULTURAL GEOGRAPHY

American Agriculture

Geography, Resources, Conservation. By Prof. Edward Higbee. Pp. x+399. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 64*s.* net.

This work is essentially a panoramic description of farming in the United States. The author's obvious interest in soil and water conservation has led him to adopt an ecological, or at least a biogeographical, approach. This gives a refreshing unity to what might otherwise have been a discursive and disjointed book.

Part 1 is a short and elementary but useful introduction to the relations between climate, soils, natural vegetation and 'land capability'. Part 2 is about the dry western half of the United States, where water is the primary limiting factor to agricultural production. The author shows very clearly how the vast irrigation schemes of the Central Valley of California and other western 'valley oases' depend on the control of both soil erosion and floods in the western mountain States. This, in turn, depends on good forest and grazing management in the non-irrigated areas. It affords an excellent example of the value of large-scale ecological integration in agriculture and forestry. Such integration calls for the planning of land and water use on a semi-continental scale. This, in its turn, raises political and social difficulties, which the author mentions; wisely, however, he refrains from offering solutions. Then, after a glimpse at the Pacific North-West, Prof. Higbee crosses the dry Great Plains, where the statistical expectation of drought dominates year-to-year changes in wheat yields and hence the structure of the local agricultural economy.

Part 3 deals with the humid and more complex eastern half of the United States. Here topography, local types of soil, and drainage problems are more important limiting factors than shortage of water, even though sprinkler irrigation is obviously rapidly increasing, particularly in market-gardens and on pastures. The corn (maize), dairy, cotton, and other types-of-farming 'belts' are successively outlined. The emphasis is perhaps more economic and less ecological than it was in Part 2, but these chapters are enhanced by some useful case studies of well-conserved farms.

The book is well illustrated, even though some of the many maps are too small to be readable. There are perhaps more tables of economic statistics than are really necessary. Further, the book ends somewhat abruptly and unexpectedly in a cranberry bog in Martha's Vineyard, Massachusetts. It lacks a concluding statement.

This is unfortunate. For it is clear to one who has visited nearly all the areas described by the author that his descriptions and bio-geographical analyses are accurate and perceptive. It would have been helpful to know what ecological and economic principles suggested themselves to his mind as a result of this most interesting and informative survey of American agriculture.

A. N. DUCKHAM

SCIENTIFIC APPLICATIONS OF SCIENCE

Operational Research in Practice

Report of a NATO Conference. Edited by Max Davies and Michel Verhulst. Pp. ix+201. (London and New York: Pergamon Press, 1958. Published for and on behalf of Advisory Group of Aeronautical Research and Development, North Atlantic Treaty Organization.) 84s. net.

IN setting up what was to become the first so-designated Operational Research Section in Fighter Command, Watson-Watt was the first to achieve the most thorough application of science itself. Radar was entirely new, and the momentum of its application carried the scientist into the heart of tactics and strategy. So it was that his formulation of the duties of operational research sections remains valid even until to-day, as Sir Solly Zuckerman emphasizes in his introduction to the report of this North Atlantic Treaty Organization conference.

But how has operational research fared since then ? It is still firmly embedded in military practice, despite the shift of emphasis from current operations to future ones, the evaluation of exercises and the development of war games. Here, due to the speed of innovation, there is little scope for hardening into conventional wisdom (to borrow from Prof. Galbraith) in regard to the conduct of military operations, the conventional wisdom of war itself being the accepted framework. But some important applications of operational research were in fields where past procedures, at one time relevant, provided the precedent. Within the Armed Services the civilian scientists were able to make a break-through, perhaps because they were unaffected by conventional wisdom.

Immediately after the Second World War the scope for scientists seemed as wide as human activity itself. The prevailing mood is now more sober, as shown by thoughtful contributions on decision-making and war games, both in civil and military situations, with the need for a theoretical rationale. Logistic and transport problems are shown to have the same basic structure, but let the user beware of an uncritical borrowing of technique, for seemingly slight differences might turn out to be important.

There is, however, one extremely important difference. In civil applications (as quoted) a 1 per cent increase in efficiency (as measured by gross profits) leading to an increase of 5 per cent in distributed profit is an achievement that firms are willing to pay for—whether or not it represents a good national use of scarce man-power. The reaction of a professional soldier is that "in a military context such improvements were seldom ever meaningful or worthwhile". He continues: "The application of operational research principles to operational research was highly desirable, but all too rare". I know of no university where an expert in "tensions in industry" from the sociology department has been invited to report on the tensions within the university.

CECIL GORDON

BACTERIAL POPULATION STUDIES IN THE CHEMOSTAT

The Dynamics of Bacterial Populations maintained in the Chemostat.

By Hermann Moser. Pp. iv+136. (Publication No. 614.) (Washington, D.C.: Carnegie Institution of Washington, 1958.) Paper, 1.15 dollars; Cloth, 1.40 dollars.

THE study of the mechanisms by which bacterial populations become better fitted to a given environment is of considerable fundamental importance. Of the various methods available for the study of such problems those using a continuous culture apparatus are especially valuable since the cells can be maintained in a state of active growth under defined conditions. In the simplest kind of continuous-culture apparatus the nutrient medium in the culture tube is automatically renewed and immediately a portion of the bacterial suspension is removed, thus maintaining (after a certain time of operation) a steady state. The chemostat superimposes another form of control on the growth, by keeping the concentration of one of the constituents of the growth medium at a sufficiently low level so that the bacterial population grows at a reduced rate which is a direct function of this concentration and is independent of all other nutrient factors.

Although the fundamental theory of growth in the chemostat has been presented by other workers, whose contribution the author generously acknowledges, the genetic theory of populations, it is claimed, has not been presented in a satisfactory way. This task the author has set himself and he proceeds to predict and discuss "the various patterns in which mutants of different kinds may accumulate in a continuously growing population and the ways in which genetic equilibria are attained in such populations". He maintains that "since we are dealing with non-sexual bacteria, the sole factors influencing the frequency of mutants in the population to be considered are the capacity to mutate, and selection". He considers both specific and periodic selection.

On the basis of these assumptions the author proceeds to set up a population model and to examine in considerable mathematical detail the numerous aspects of the problem. The mathematical treatment is the most comprehensive the reviewer has seen and it is recommended to anyone interested in this subject. However, the reviewer feels that it is a pity that the fundamental assumptions of mutation followed by selection were not more rigorously confirmed. It would have provided a better balance if the complementary mechanism of adaptation by non-genetic means had been considered (if only to be rejected), especially since the theory of periodic selection has been challenged for at least one example.

The book is well written and is produced to the usual high standard of the publications of the Carnegie Institution of Washington.

A. C. R. DEAN

SCIENTIFIC CO-OPERATION WITHIN THE BRITISH COMMONWEALTH*

By H.R.H. THE DUKE OF EDINBURGH, K.G., K.T., F.R.S.

WE often hear about the invisible ties of friendship and trust which bind together the members of the Commonwealth. We do not hear quite so much about the practical advantages of membership or the amount of quiet unspectacular work which is going on to the mutual benefit of the Commonwealth as a whole. I must admit that it came as quite a surprise to me to discover the amount of useful co-operation in science which is going on within the Commonwealth to-day. I was also delighted to find that this co-operation has been active for quite a long time. It is always the same, and I am sure many have also noticed that there is no better way of finding out about a subject than having to speak about it.

Conferences

One of the first things I discovered was that this address, the subject of which you chose for me, has come at a most appropriate moment because the very first formal step in scientific co-operation was taken exactly fifty years ago. In the year 1909 the Entomological Research Committee for Tropical Africa was formed with headquarters at the British Museum (Natural History), London. The funds came from the African Colonies and the United Kingdom, and it made the first systematic collection and study of insects injurious to men, animals and crops in East and West Africa.

Although this was a very modest venture—the annual budget only amounted to £2,000—yet it was the start of great things.

The venture was discussed at the Imperial Conference of 1911, and in 1913 it became the Imperial Bureau of Entomology, with two main functions: (1) "the identification of all injurious insects sent in by officers attached to departments of Public Health in countries in the Empire"; (2) "to issue a monthly periodical giving summaries of all current literature both British and foreign, dealing with noxious insects, whether agricultural pests or disease carriers". In the same year it published its first journal of abstracts.

Next, the Imperial War Conference of 1918 established the Imperial Bureaux (now the Commonwealth Institute) of Mycology at Kew, and it was the Imperial Agricultural Research Conference of 1927 that set up the first Commonwealth Agricultural Bureaux.

In 1933 the Imperial Committee on Economic Consultation and Co-operation met, and one of its decisions was that there should be a scientific conference every five years which, among other things, was to review the working of the Commonwealth Agricultural Bureaux.

It is therefore plain that this subject of Commonwealth co-operation in science has been given serious consideration for a good many years by many hard-headed and practical people. I also want to make it clear that throughout the story the endeavour has been to benefit the Commonwealth as a whole and not the particular interests of any one country.

Therefore, to resume the story. The first Commonwealth Scientific Conference and First Review Conference of the Commonwealth Agricultural Bureaux was held in London in 1936, and, as a result, two further Bureaux were added. Since then, there have been review conferences in 1946, 1950 and 1955. These concerned themselves mostly with finance and administration, but the last one recommended that the National Institute of Agricultural Engineering should compile and issue abstracts for Commonwealth use.

At the present moment there are three Commonwealth Institutes: the Commonwealth Institute of Entomology at the British Museum (Natural History); the Commonwealth Mycological Institute at Kew (where I opened a new building in 1955); the Commonwealth Institute of Biological Control at the Science Building in Ottawa. There are ten Commonwealth Agricultural Bureaux dealing with the following subjects: animal breeding and genetics at Edinburgh; animal health at Weybridge; animal nutrition at Aberdeen; dairy science and technology at Reading (which I visited in 1954); forestry at Oxford; helminthology at St. Albans; horticulture and plantation crops at East Malling (which I visited in 1957); pastures and field crops at Hurley (which I visited in 1958); plant breeding and genetics at Cambridge; soils at Rothamsted (which I visited in 1954).

Each Institute or Bureau is attached to an institute or laboratory or university department doing active work in that particular science.

A similar but separate undertaking is the Commonwealth Geological Liaison Office, which has been conducting a survey of the mineral resources of the Commonwealth for the past six years. Sixty-five reports have been issued, and the Office has now started to review the position of each of the minerals for the second time.

These organizations are probably the most practical and scientifically useful co-operative undertakings in the Commonwealth to-day. However, that is not the end of the story. At the 1930 Imperial Conference two committees were formed to go into the subject of industrial and fundamental standards. This resulted in the Standards bodies of the Commonwealth countries maintaining regular and systematic consultations, and in 1946 they met in conference in London and again in 1957 in Delhi. There is every reason to believe that they will go on meeting in future because their work has been most rewarding and is proving very valuable to science and industry as well as to Commonwealth trade.

The Second World War inspired the formation of the British Commonwealth Scientific Offices in London and Washington. In them work the Scientific Liaison Officers attached to the High Commissioners' or Ambassadors' staffs. They run themselves and a great many other things besides, and they are without any doubt the most lively force in Commonwealth scientific co-operation at this moment.

I must refer to five more conferences which between them have stimulated a new wave of thought and activity on this subject of scientific co-operation. In 1946 the Royal Society in London invited Commonwealth scientists to a conference in which they could speak as individual scientists. Immediately following this conference the Commonwealth Governments organized an official science conference where matters arising out of the Royal Society meetings could be discussed and official action taken. The reports of these two conferences make fascinating reading. First, because of the very obvious harmony and friendly spirit which existed throughout the discussions and, secondly, because of the immense scope of the discussions, which touched every possible aspect of Commonwealth scientific co-operation.

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* Substance of an Address delivered at the Annual Meeting of the Pakistan Association for the Advancement of Science in Karachi on February 7.

The main topics of the discussions were: agricultural science; medical science; nutrition and special problems of the Commonwealth; mapping and exploration by air; scientific information services in the Commonwealth; interchange of scientists; co-operation with international scientific organizations; standards measurement; interchange of scientific material; land utilization and conservation; mineral resources of the Commonwealth; natural products and chemical industries which might use them; need for fundamental research; co-ordination of scientific work in Africa.

This last problem was considered at a special conference in London in 1949 and in Paris in 1950, and, as a result, the Commission for Technical Co-operation in Africa South of the Sahara, known as C.C.T.A., was formed. The members are: Belgium, the Federation of Rhodesia and Nyasaland, France, Portugal, the Union of South Africa and the United Kingdom. The Commission, among other things, convenes technical conferences, administers the Inter-African bureaux on various subjects, administers the Inter-African Research Fund and has established a number of advisory committees in various fields.

The third important conference was the Royal Society Scientific Information Conference of 1948 which, as its name implies, dealt with the problems of the collection, reproduction, abstraction and distribution of scientific information, particularly within the Commonwealth. This was, in fact, one of the first specialist conferences which had been recommended by the Royal Society meeting of 1946. The Conference suggested the formation of a Standing Committee on Information Services in order to "provide machinery for the interchange and coordination of ideas and information" which are emerging from the British Commonwealth as a result of the Conference.

The fourth Conference which is of particular interest was the British Commonwealth Scientific Conference held in Australia in 1952. I say particular interest because it was the first of this series of conferences attended by representatives from Pakistan and Ceylon. As to the business of the Conference I would like to quote a few sentences from the report: "The Conference felt that . . . the day to day contact of the liaison officers provided an effective system of collaboration which necessitated only occasional meetings of the heads of the official scientific organizations" and, later, "In addition to discussing how best to maintain collaboration the Conference dealt with a wide range of questions, including the application of the results of scientific research, the development of information services, the movement of scientists within the Commonwealth, the relations of the constituent organizations with international bodies concerned with science or its application and the provision of technical man-power to assist underdeveloped countries". Again, "It was agreed as particularly important that developments should be watched in the following subjects: industrial microbiology, research in . . . the utilization of low-grade ores, research on the utilization of solar energy by both physical and biological means, infertility of ruminant animals, agricultural engineering". In addition, it discussed the organization of national research bodies.

The Conference was opened by Mr. Menzies, the Prime Minister of Australia, with a most eloquent appeal that the results of scientific research should find their way as quickly as possible into the hands of those who need to have the results.

The fifth Conference was the outcome of the Commonwealth Prime Ministers' meeting in 1957. They recommended an informal meeting of Commonwealth scientists to discuss the use of nuclear energy for civil purposes. The meeting was held during September 15–20, 1958, and every Commonwealth country except Malaya was represented. Not all the delegates were nuclear scientists because the main intention of the Conference was to develop a sense of Commonwealth partnership and inter-reliance in the development and application of nuclear energy. For example, although radioisotopes are produced by nuclear science, they can be used by many other interests—medical, biological, agricultural and industrial.

In the course of their five-day meeting the Commonwealth scientists did a bit of travelling and visited Harwell, the nuclear power station building at Bradwell, Calder Hall and Dounreay. They had one non-scientific interlude when the whole party, numbering about thirty-five delegates, came to lunch with The Queen and myself at Balmoral, and I was delighted to find Dr. Nazir Ahmad and Dr. Ghani among the party.

The latest of this series of conferences was held when the British Commonwealth Scientific Committee met in Canada in August 1958. At this meeting Ghana and Malaya took their places for the first time. The meeting decided to abolish the full-scale scientific conferences and substitute regular meetings of the British Commonwealth Scientific Committee consisting of the heads of the national research organizations of the Commonwealth countries. The Committee has decided to meet again in London in 1960.

The Colombo Plan

All these conferences have given point and direction to scientific co-operation, but no discussion on this subject would be complete without a reference to the Colombo Plan, particularly the technical co-operation scheme. The Plan was the outcome of a meeting of the Commonwealth Foreign Ministers at Colombo in 1950. The main part of the Plan deals, of course, with economic matters; but under the technical co-operation scheme there is a very considerable movement of students and experts in scientific and technological subjects between Commonwealth countries as well as between other south-east Asia countries and the United States. In the past eight years nearly 7,000 trainees and students have received instruction and just over 1,000 experts have been exchanged between the nineteen countries taking part—eleven of them Commonwealth. Of these, only three have not yet received any help and only five have so far been unable to offer any help.

That, I think, is ample proof that this is a real co-operative effort.

Just as an illustration, it may interest you to know that, for example, Pakistan has received help from Australia, New Zealand, Canada and the United Kingdom, and has, in her turn, helped Burma, Japan, Malaya, the Philippines and Ceylon.

There are, of course, many schemes being developed under the Colombo Plan in Pakistan; but I am particularly interested in the Warsak hydro-electric and irrigation scheme because I hope to see how it is getting on in a few days time. It seems to be an excellent example of Commonwealth co-operation, as Canada is providing considerable technical assistance and is footing more than half the bill of 60 million dollars.

The British Association

Although, strictly speaking, the British Association is not primarily concerned with scientific co-operation within the Commonwealth, it has played quite an interesting part in the development of science and scientific institutions in Commonwealth countries. As the representative of the British Association at this meeting, I hope you will forgive me if I say a few words about its contribution. The fact is that as early as 1884 the British Association held its annual meeting for the first time out of the United Kingdom, in Montreal; in 1897 it went to Toronto, in 1905 it went to South Africa, in 1909 it was back in Canada at Winnipeg, and in 1914 it went to Australia. Since then it has been to Toronto again in 1924 and South Africa in 1929. In each case the report makes it quite clear that the personal contacts which were made at those meetings were considered highly valuable, while the suggestions made by the different sections about research projects were almost invariably put into effect. It was not a one-way business either. Visitors to the 1897 Toronto meeting were greatly impressed by the agricultural experimental stations established in Canada and it was recommended that the Council should approach the Home Government with a view to their imitation in Britain.

Modesty forbids me to suggest that any other Association for the Advancement of Science owes anything to the British Association, but they all have one pleasant feature in common. Members of any Association within the Commonwealth are welcome at any Association's meeting and every Association makes a point of inviting a delegation from other Associations to its meetings, and that is why I am here to-day.

Movement of Scientists within the Commonwealth

That, then, is a very general summary of the history and machinery of scientific co-operation within the Commonwealth; but there are, in fact, many other, perhaps more isolated, instances where the fact of the existence of the Commonwealth has affected the course of science.

Perhaps the most convincing example I can choose is the case of Lord Rutherford. Born in New Zealand in 1871, he went to Cambridge as an 1851 Exhibitioner, and from there he went to McGill University in Canada as professor of physics, where he became famous for his brilliant work on radioactivity. In 1907 he moved to Manchester, where he developed his nuclear theory of the atom and accomplished the first artificial transmutation of matter by bombardment with particles. Returning to Cambridge in 1919 as Cavendish professor, he saw his prediction of the existence of the neutron realized by Chadwick.

Two others are of particular interest. Sir Ronald Ross was born in India in 1857 and later trained as a doctor in England. Fired by the vision of Patrick Manson, he returned to India determined to find out the cause of malaria. Within three years he pinned it down to the *Anopheles* mosquito and thus paved the way for the control of one of the worst scourges of mankind.

In a different field Sir Claude Inglis is another example. Trained at Dublin, he went to Sind Irrigation in 1906, and thirteen years later he established the first large-scale hydraulic model station in the world at Poona. In 1945 he returned to England to design and direct the Hydraulics Research Station at Wallingford, and he is now engaged on the Karnafuli scheme for Pakistan.

There is, of course, an excellent example much nearer home, as the University of Lahore recently discovered when they lost Prof. A. Salam to the Imperial College of Science and Technology, London. However, the main thing is that his work on elementary particles will continue to be available to Commonwealth and world science wherever he works in the free world.

This freedom of movement, and the fact that most scientists within the Commonwealth use the same language, are conditions which we should exploit to the greatest extent for the benefit of scientists and through them of science and, ultimately, the people of the whole world.

It has long been recognized that this ability to move about freely within the Commonwealth is a unique advantage, and all the conferences of scientific co-operation have stressed the need for a greater movement of scientists between one country and another.

I was particularly interested to discover that this problem was first tackled as long ago as 1890 by the Commissioners of the Great Exhibition of 1851. In the regulations for their Science Research Scholarships it says: "The Scholarships are 'post-graduate', and are intended to enable selected students of overseas Universities who have already completed a full University course and given evidence of capacity for scientific investigation to devote themselves for two years to research work under conditions most likely to equip them for practical service in the scientific life of the Commonwealth". The Scholarships are tenable anywhere except in the country in which the student has received his scientific education. This scheme was the first of its kind and set the pattern for subsequent awards from other organizations. In 1958 the Commissioners made twenty-five awards.

I am afraid it is not a simple matter to find out exactly how many Commonwealth scientists are in fact studying or working in other Commonwealth countries under some kind of assisted exchange or scholarship scheme. The difficulty arises because the schemes are many and various and are operated by every kind of trust and benefaction.

So far as the United Kingdom is concerned, there are more than 500 schemes in operation designed to help people to study and work in that country, and some 124 to send people out of the United Kingdom. Apart from the 1851 Exhibition Scholarships, the Royal Society and the Nuffield Foundation run a bursaries scheme, and the British Council runs a universities exchange scheme.

The same sort of thing is happening outside the United Kingdom. For example, the National Research Council of Canada offers post-doctorate Fellowships, and, since 1948, some 574 research workers from other Commonwealth countries have worked in Canada, and, at the same time, about 40 Canadians each year are enabled to work in other countries. Under the Colombo Plan, Australia has taken 2,286 students from South-east Asia between 1951 and 1958 at a cost of £3 million.

Up to thirty years ago the Commonwealth and Colonial Empire looked to the United Kingdom as the scientific centre and no one spent much money on scientific research. However, in the past twenty years alone Government expenditure on research throughout the Commonwealth has risen by an estimated factor of fifteen.

Original Scientific Work in Commonwealth Countries

Statistics are well known to be misleading when handled by amateurs ; even experts can make them do strange things, and in any event numbers in science give no clue to quality. Let me just remind you of some of the original scientific work carried out in Commonwealth countries other than the United Kingdom. It is an interesting fact that no less than forty-two Nobel Awards have been won by Commonwealth scientists. But, to be more specific, in 1921 Sir Frederick Banting, working with McLeod and Best in Canada, isolated insulin. Sir Macfarlane Burnet in Australia has immensely advanced our knowledge of viruses and their diseases. South African workers have recently developed the tellurometer, which measures base lines for surveying by radar in a fraction of the time needed by conventional methods. Also in South Africa, Sir Arnold Theiler and P. J. du Toit discovered that lack of phosphorus in the soil was the cause of widespread botulism in cattle. Workers in Australia and New Zealand followed this with their discovery of the importance of trace elements in plant and animal health. Edwards in India developed a vaccine against rinderpest. Scientists in Canada have been fighting a long and unremitting battle against black rust in wheat and here in Pakistan research is active in this field as well as in mechanical rice cultivation and in cotton breeding, all of which has an international reputation. The names of Venkata Raman in physics and Ramanujan in mathematics are respected and admired throughout the world.

All this convinces me that the whole Commonwealth would benefit greatly from a larger movement of scientists either as students, research workers, scientific expedition members or as teachers. The important thing, therefore, is to devise practical and simple machinery to encourage this movement to take place.

The present pattern of scientific co-operation within the Commonwealth can be divided into five parts : (1) the regular discussion of general scientific problems and of problems particular to the Commonwealth ; (2) the discussion of the problems of the administration of science and research ; (3) the regular exchange of scientific information ; (4) the movement of scientists ; (5) technical help and advice.

(1) and (2) are achieved by regular conferences and contacts between the official research organizations. (3) is achieved by the British Commonwealth Scientific Offices and the Commonwealth Agricultural Bureaux. (4) is achieved by bursaries, scholarships, lectureships and various other schemes of assisted exchange, while the Colombo Plan has encouraged tremendous progress in (4) and (5).

I ought to add at this point that nothing I have said refers to the personal and informal contacts which exist between individual scientists within the Commonwealth. The total of this informal co-operation is probably greater than anything organized through more or less official channels, but of course there are no statistics.

Suggestions to improve Scientific Co-operation

So far I have only dealt with facts. Now I am going to be rather more rash and put forward some suggestions to increase the amount of co-operation between Commonwealth countries. I will not go so far as to say that these suggestions are possible in practice. I would merely say that they are desirable.

I would like to see the system of the Commonwealth Agricultural Bureaux extended to other sciences and set up in whichever country has the greatest interest in the particular subject. Secondly, I would like to see the system of the British Commonwealth Scientific Offices extended to other Commonwealth countries ; this may be a bit premature but, as it is, many Commonwealth countries are doing original research in subjects which are of great interest to others. Thirdly, it would make a wonderful story if countries could pool their resources and plan together the attack on common problems. I say deliberately that it would make a nice story because I do not think scientists or anyone else work that way. It always seems to me that individual laboratories like to attack problems in their own way even though they are quite willing, indeed eager, to discuss the results with anyone who is interested. Therefore, I believe the most we can hope for is a broad agreement about which problems appear to be most important for the time being, followed by a frank exchange of the results of research.

Next I would like to see joint action on scientific problems which affect Commonwealth industry, commerce and trade. Although more than half the research associations in the United Kingdom have Commonwealth members and the flow of technical information is not impeded in any way, except if the industries are in direct competition, I am convinced that wider membership of research associations and more co-operation between research associations in all the Commonwealth countries is both possible and desirable.

However, I am not blind to the complications. Scientists very naturally imagine that anything new which they discover and which seems to them important must be obviously immediately useful to industry. In fact, the most shattering scientific advances may not be of any practical use for many years while some trifling nonsense produced almost by mistake in a laboratory working on, for example, hydraulics may turn out to be vitally valuable to the boot and shoe industry. Furthermore, even if it can be proved quite easily that a particular discovery will revolutionize cotton farming, it does not necessarily follow that cotton farmers will accept and apply the discovery just like that.

For example, I understand that the Laboratories of the Pakistan Council for Industrial Research have, in fact, completed sixteen processes making use of indigenous materials which are ready for exploitation by industrialists. Some have already been taken up, but I would not be surprised to hear the chairman of that Council say that "you can lead an industrialist to the waters of science but you can't make him drink".

There is only one way to ensure the early application of scientific research. It is essential that industry and all other potential users of scientific production should be as closely associated with the research organization as possible at all times. Industries and farmers must be encouraged to make direct use of research facilities by asking questions, and they must also be made to feel a personal interest in the research activities by being asked to take part in experiments and developments.

The rules of human nature are not really very complex. If somebody offers you advice, the chances are you will tell him to mind his own business; if, on the other hand, he asks you for your advice and help, you are probably rather flattered.

The key to the problem of the application of scientific discovery is the closest collaboration between the research establishments and industry.

Benefits of Commonwealth Scientific Co-operation

So far I have assumed that there is some advantage to be gained from Commonwealth co-operation in science. I have assumed that in the long run the ordinary people of the countries of the Commonwealth will be better off if we make the fullest use of the freedom of movement of scientists and scientific ideas and a common scientific language. However, if this is true, if this business of co-operation is really and practically worth while, there must be some concrete examples which provide conclusive proof. Naturally, I would not have raised this point unless I had that proof.

I think we all agree that where it is possible scientific co-operation should be truly international, and enterprises like the International Geophysical Year, the Organization for European Economic Co-operation, and, on a smaller scale, the Commission for Technical Co-operation in Africa South of the Sahara, and the Colombo Plan show that this can happen. Nevertheless, in spite of the wide differences between the circumstances of the Commonwealth countries, the fact that they have similar institutions often makes it possible to organize co-operation on a Commonwealth scale when it is not possible internationally. For example, international efforts were made for years, without success, to organize the preparation of comprehensive catalogues of cultures of micro-organisms. Preparation of such catalogues within the Commonwealth was organized at a meeting lasting three days.

The Commonwealth operates an "Index of Translations", so that a scientific paper translated anywhere in the Commonwealth is available to any research worker. The Organization for European Economic Co-operation has so far failed in its efforts to organize a similar index.

To add weight to the argument I have chosen two examples which particularly concern Pakistan. Agriculture is, and must remain, the most important industry of Pakistan. For many years the soil will remain its main source of wealth. Anything therefore which advances the art and science of agriculture is vital.

After the First World War investigations were started by meteorologists in England to investigate the behaviour of the layer of air within 100 ft. of the ground about which practically nothing was known. The immediate purpose of this work was military—to study the rate of evaporation from the ground of poisonous gases and the travel of gas and smoke clouds. This work has been continued at Cambridge, and from measurements of the humidity and wind velocity at different heights an electronic computer can calculate the mean water-loss of crops hour by hour. It is then possible to estimate the water consumption of farm crops by physical measurements of the micro-climate. It is a bit early to say what the practical application is going to be; but it shows how scientific research planned for one object in one part of the Commonwealth can produce unexpected techniques and results for other purposes in other places. I hope this matter will be of particular interest to the president of the Pakistan Association for the Advancement of Science, whose work on soil science is well known and who now controls agricultural development in East Pakistan.

The second example concerns a specific investigation. A model investigation is now in progress at the Wallingford Hydraulics Research Station in England to determine the causes of the changes in the bed of the mouth of the Karnafuli River in East Pakistan so that the conditions at the port of Chittagong can be improved and stabilized. This particular piece of work is being done under the Colombo Plan.

In neither case has there been any question of attempting to gain either economic or political advantage. There has been no question of prestige or personal glory. These two cases are typical of hundreds which are in the pipe-lines of Commonwealth co-operation in science, pipe-lines which should be made to carry information and ideas in both directions between all members of the Commonwealth of Nations.

I do not really believe that anyone can seriously doubt that science devoted to fundamental research and the application of natural knowledge to civil and peaceful ends is capable of bestowing the most wonderful benefits upon mankind. In our own time it has brought about a period of almost headlong industrial and therefore economic expansion. I need scarcely emphasize the profound effect which science has had upon medicine and agriculture. (Although the cynic might say that science has simply made it possible for agriculture just to keep pace with the growing demand for food which is a direct result of the effects of improved medical practice.) All the same, there is no use denying that the developments brought about by scientific research have produced a whole host of new problems; problems which can only be alleviated by humane and thoughtful administration; problems which scientists, in company with all other professional groups, must face and overcome as ordinary thinking human beings.

By far the most harrowing problem is the use of science for destructive and warlike purposes. Everyone deplores it; but there is obviously no immediate solution. However, I firmly believe that if we can go on building on this foundation of peaceful co-operation between Commonwealth countries in all spheres of activity, we shall be doing much more than simply helping ourselves; we shall eventually have a structure which will give hope and confidence to all the men and nations of the world and then science at last will be freed for ever from the grim necessity to invent weapons of destruction.

RADIATION AROUND THE EARTH TO A RADIAL DISTANCE OF 107,400 KM.

By PROF. JAMES A. VAN ALLEN and LOUIS A. FRANK

State University of Iowa, Iowa City

Introduction

FOLLOWING the discovery[1-4] of the existence, in a region around the Earth, of a high intensity of corpuscular radiation temporarily trapped in the Earth's magnetic field, it became evident that observations to very great radial distances from the Earth would be desirable in determining the structure and extent of the radiation belt. A proposal[5] for such an undertaking was favourably received by the U.S. National Committee for the International Geophysical Year. Discussions soon thereafter with Drs. William H. Pickering and Eberhardt Rechtin of the Jet Propulsion Laboratory of the California Institute of Technology led to the formulation of a plan for including radiation detectors in one of the payloads of the planned deep-space probes of the U.S. Army Ballistic Missile Agency.

It was agreed that the State University of Iowa group would select, calibrate, and provide detectors and would recommend suitable dynamic ranges for the measurements as indicated by previous satellite observations; that the Jet Propulsion Laboratory would develop and build the necessary circuitry and telemetry and would do the payload engineering; and that the two groups would co-operatively test and calibrate the completed payload and reduce the flight observations. This plan was carried out.

The vehicular part of the programme was already well advanced by the U.S. Army Ballistic Missile Agency and the Jet Propulsion Laboratory (later under the general supervision of the National Aeronautics and Space Administration), and special telemetry receiving stations were being established at Mayaguez in Puerto Rico and at Goldstone Lake, California, by the Jet Propulsion Laboratory.

Radiation Detectors

Of a total payload weight of 13 lb., about 3 lb. was available for the radiation apparatus.

It was decided to use two Geiger–Müller tubes as basic detectors.

(*a*) The first was a standard, halogen-quenched Anton type 302. The regulated high-voltage supply and the scalers were similar to those previously developed at the State University of Iowa for satellite use[6]. Ingenious modifications of the circuits were made by Messrs. W. H. Victor, D. Slaughter and C. Josias of the Jet Propulsion Laboratory to provide for higher counting rates and to permit the mixed transmission on a single, continuous telemetry channel of the counting rate scaled by three different factors: 2^9 (= 512), 2^{13} (= 8,192), and 2^{17} (= 131,072). The experimental value of the dead-time τ of the system was 31·9 μsec. and the apparent counting rate r was well represented by:

$$r = R \exp(-R\tau) \qquad (1)$$

where R is the true counting rate. The apparent counting rate r was an increasing function of R up to a value of R of about 33,000 per sec., then a decreasing function of R up to a usable value of R of about 250,000 per sec., with:

$$r_{\text{max.}} = (e\tau)^{-1} = 11{,}550 \text{ per sec.} \qquad (2)$$

The absolute omnidirectional geometrical factor G_0 of the 302 Geiger–Müller tube was:

$$G_0 = 0{\cdot}75 \text{ cm.}^2 \qquad (3)$$

with an uncertainty of ± 20 per cent, at the present date of writing. The uncertainty in the final value of G_0 will be about ± 10 per cent upon completion of a variety of tests on a 'standard' comparison tube. The absolute efficiency of the tube for fast, singly charged, ionizing particles was 0·83 ± 0·05 (also being refined). Hence, if the counter is actuated only by direct penetrations of charged particles, the absolute omnidirectional intensity J_0 (flux through a sphere of 1 cm.^{2} cross-section) is given by:

$$J_0 = 1{\cdot}6\, R, \qquad (4)$$

with an absolute uncertainty of ± 20 per cent.

An extensive series of X-ray and γ-ray calibrations of the tube was also made using an integrating Victoreen r.-meter as the standard of exposure-level. Discussion of these calibrations is omitted in this preliminary report. The shielding of this counter had its minimum value of 0·67 gm./cm.^{2} (60 per cent stainless steel and 40 per cent fibre glass and 'Micarta') over a solid angle of about $4\pi/3$ steradians, an 'average' value of 1·0 gm./cm.^{2} over about 80 per cent of 4π steradians and several gm./cm.^{2} over the remaining 20 per cent. It may be noted that the 1·0 gm./cm.^{2} shielding corresponds to the range of 30 MeV. protons or to the extrapolated range of 2·2-MeV. electrons or to the absorption mean free path of 50-keV. X-rays.

(*b*) The second Geiger–Müller tube was one of a batch of tubes specially built for this experiment by the Anton Electronic Laboratories and designated Anton type 213. Its effective omnidirectional geometric factor was about 0·12 of the 302 and it was operated as a counting rate meter with the time-average anode current applied to a d.c. amplifier designed at the Jet Propulsion Laboratory. No in-flight calibration was provided, but special care was

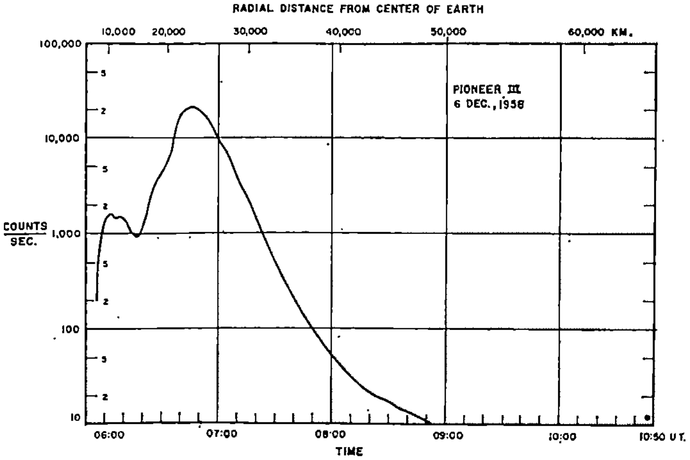

Fig. 1. Semi-log plot of true counting rate R of the 302 Geiger–Müller tube versus time of observation on the out-bound leg of the flight of *Pioneer III*. Radial distance from the centre of the Earth is shown at the top of the figure. The geographical longitude during the period shown was 30° W. at 0600; 0° at 0630; 5° E. at 0700; 4·6° E. at 0730; 2° E. at 0800; 2° W. at 0830. The curve is based on 93 plotted points. Absolute accuracy of individual points is ± 3 per cent from 0556 to 0630; ± 10 per cent from 0630 to 0720; ± 3 per cent from 0720 to 0800 and ± 2 per cent from 0800 to 0850. The lesser absolute accuracy at the higher counting rates is due to inaccuracy of equation (1) of the text

taken in reducing the dependence of the telemetered output upon supply voltages and environmental conditions. The output was a monotonically increasing function of the radiation-level to which the counter was exposed, being linear for low levels and approaching an asymptotic, saturated value for very high levels. Thus, this detector served as a crude radiation-survey device in its own right. More important, its operating characteristics were adjusted so that it served as an 'ambiguity resolver' for the 302, that is, its output was used to decide on which branch of the characteristic curve (cf. equations 1 and 2) of the 302 the latter tube was operating at any instant. This property of the 213 system was an essential one in interpreting the flight observations (see below). The shielding of the 213 tube was nearly identical to that of the 302.

Transmission of Data

All aspects of the radio-telemetry system were handled by the Jet Propulsion Laboratory. A new transmitter, radiating about 150 mW. at 960·05 Mc./sec., was developed and used for the first time. The transmitter was phase modulated by the summed output of three audio-frequency subcarrier oscillators. Channel 1 (centre frequency 400 cycles/sec.) transmitted payload temperature and several other functions. Channel 2 (centre frequency 560 cycles/sec.) transmitted the quasi-d.c. output of the 213 Geiger–Müller tube. Channel 3 (centre frequency 730 cycles/sec.) changed frequency discontinuously (with an effective time constant of 10 sec.) among eight different states corresponding to the output of the composite scaling circuit connected to the 302 Geiger–Müller tube.

The two primary receiving stations were established by the Jet Propulsion Laboratory for the Army probe firings: one near Mayaguez, Puerto Rico, with a 10-ft. dish and one at Goldstone Lake, California, with an 86-ft. dish. Auxiliary receiving stations were located near the launching site at Cape Canaveral, Florida.

Vehicle and Trajectory

The overall vehicular engineering of *Pioneer III* was done jointly by the U.S. Army Ballistic Missile Agency, under the technical direction of Dr. Wernher von Braun and by the Jet Propulsion Laboratory. The first stage was a modified *Jupiter*. The second, third and fourth ('high speed') stages were solid-fuelled Jet Propulsion Laboratory rockets.

The actual flight trajectory was determined by the Jet Propulsion Laboratory by a complex 'best fitting' technique to directional and Doppler-frequency observations from the several receiving stations. The trajectory which has been used in preparing the present article is a preliminary one, the accuracy of which during the re-entry phase is estimated to be of the order of 1,000 km. The outgoing portion of the trajectory is known to an accuracy of ± 100 km. to radial distances of the order of several thousand kilometres. A cumulative deterioration of accuracy occurs thereafter. Recalculation of the 'final' trajectory is still in process. The spatial plots of radiation intensity will be appropriately adjusted in a later article.

In addition, the preliminary trajectory has been converted to eccentric geomagnetic co-ordinates through the courtesy of Dr. Charles Lundquist of the U.S. Army Ballistic Missile Agency.

Log of Flight and Telemetry (*Pioneer III*)

(*a*) *Log of flight.* Launch from Cape Canaveral, Florida, at 0545 U.T., December 6, 1958. (28·5° N., 80·8° W.) Burn-out velocity (space fixed): 10·68 km./sec. Apogee: 108,700 km. radial distance from centre of Earth, geographic latitude 23·74° S., geographic longitude 145·5° E. at 0049 U.T., December 7.

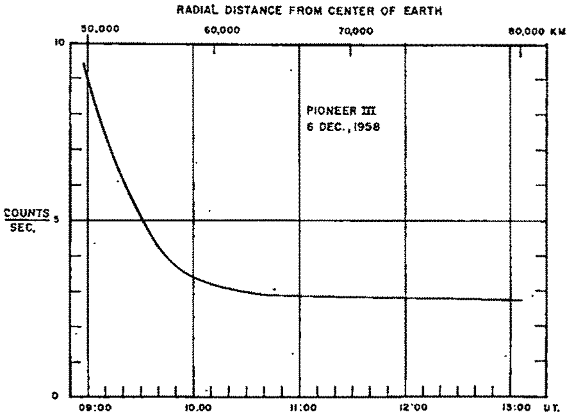

Fig. 2. Linear plot of true counting rate R of the 302 Geiger–Müller tube versus time of observation on the out-bound leg of the flight of *Pioneer III*. The geographical longitude during the period shown was 7° W. at 0900; 17° W. at 1000; 29° W. at 1100; 42° W. at 1200; and 54° W. at 1300. The plot is based on 38 plotted points of ± 4 per cent accuracy each

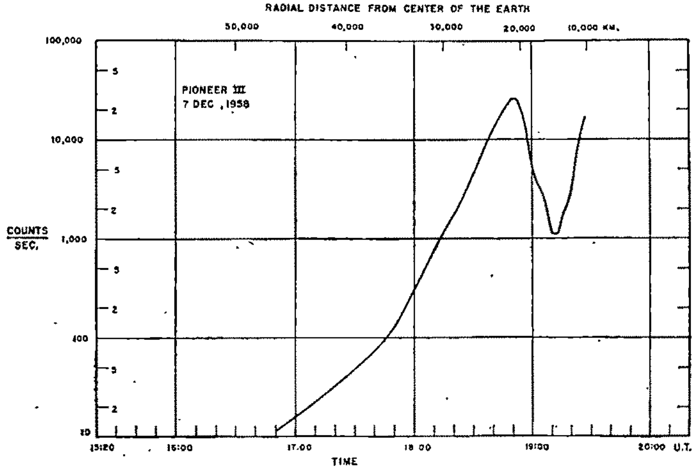

Fig. 3. Semi-log plot of true counting rate *R* of the 302 Geiger–Müller tube versus time of observation on the in-bound leg of the flight of *Pioneer III*. The geographical longitude during the period shown was 61° W. at 1700; 65° W. at 1800; 64° W. at 1830; 56° W. at 1900; 25° W. at 1930; and 0° at 1936. The curve is based on 48 plotted points with accuracy of each point ± 2 per cent from 1650 to 1820 and no greater than ± 10 per cent thereafter

Extrapolated impact with the Earth: geographic latitude 16·18° N., geographic longitude 20·30° E. at 1943 U.T., December 7.

(*b*) *Log of telemetry.* December 6: 0549–1410 U.T. Puerto Rico—solid telemetry; 1330–2213 U.T. Goldstone Lake—solid telemetry. December 7: 1154–1425 U.T. Puerto Rico—radio-frequency received but signal too weak for readable telemetry; 1425–1520 U.T. Puerto Rico—telemetry intermittently readable; 1520–1930 U.T. Puerto Rico—solid telemetry.

Radiation Observations

Due to excellent telemetry (see previous section), continuous radiation observations were obtained on the out-bound leg of the trajectory to a radial distance from the centre of the Earth of 107,400 km. (nearly to apogee) and from 60,000 km. to 9,400 km. on the in-bound leg.

The true counting rate of the 302 tube is plotted and presented in Figs. 1, 2 and 3. The output of the 213 tube, not shown in detail in the present article, was consistent with that of the 302 tube throughout and in addition served the important function of ambiguity-resolver, mentioned above, in assuring that there are indeed two distinct peaks of intensity separated by relative minima as shown in Figs. 1 and 3.

Fig. 4 gives a schematic view of the observations with selected values of the true counting rate of the 302 Geiger–Müller tube marked on a meridian plane-polar co-ordinate plot of the trajectory.

Intensity-Structure of the Region of Trapped Radiation

There are two distinct, widely separated zones of high intensity. In our previous work[7,8] with satellite 1958ε it was found that contours of constant counting rate of a Geiger–Müller tube very similar to the 302 tube of *Pioneer III*, though somewhat more heavily shielded, suggested a dough-nut-shaped region centred on the geomagnetic equator as being the region of maximum intensity. In addition, the contours showed tongue-like regions of radiation extending downward toward the Earth at high geomagnetic latitude, both north and south. The high-latitude edges of these tongues were near the low-latitude edges of the usual auroral zones, a suggestive fact which has been discussed[7,8]. In Fig. 8 of ref. 7 a speculative extension of the contours observed with satellite 1958ε was presented. The diagram given therein was one of two types which we had sketched as plausible extensions of the observed contours. The other one of the two, particularly advocated by C. E. McIlwain of this laboratory, regarded the high-latitude, tongue-like contours as the tips of an outer, banana-shaped region (in meridian cross-section). This view implied a second maximum in intensity as one passes outwards from the Earth in the plane of the geomagnetic equator. The new *Pioneer III* observations show that this second diagram was indeed more nearly true than the one previously published. Our revised and present best picture of the situation is given in Fig. 5. This diagram harmonizes in a single representation our very extensive observations with satellite 1958ε (up to altitudes of 2,200 km.) and the new observations with *Pioneer III*. The latter were the 'one-dimensional' observations along the curved trajectory lines shown in Fig. 5.

The heavy black dots on these lines show specific points through which the contours were

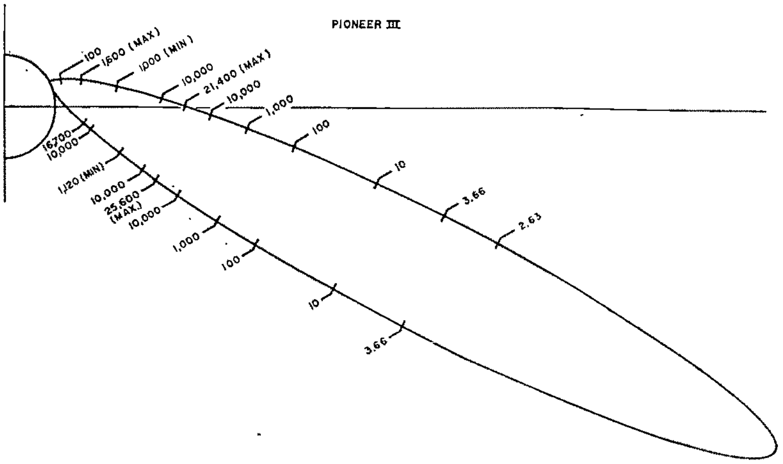

Fig. 4. A geographical plot, to scale, of the projection on a (rotating) meridian plane of the trajectory of *Pioneer III*. The semicircle at the left represents the cross-section of the solid Earth. Polar co-ordinates are radial distance from the centre of the Earth and the geographical latitude. The vertical axis is the geographical axis of the Earth with the north end up. The numbers are true counting rates *R* at selected positions along the trajectory. The out-bound leg of the trajectory is the upper portion of the curved line

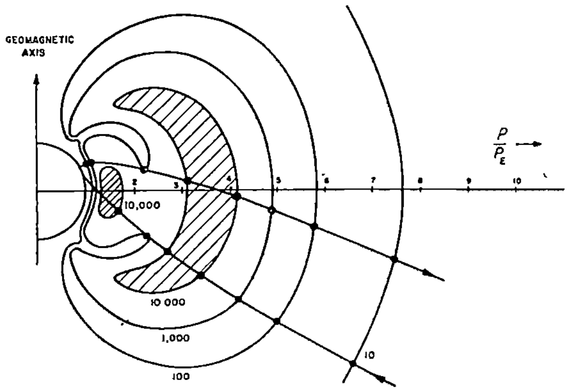

Fig. 5. A plot in a geomagnetic meridian plane of the intensity-structure of the radiation region around the Earth. The numbers associated with the several contours of constant intensity are the true counting rates R of the Geiger–Müller tube in *Pioneer III* or in satellite 1958ε. Within the two cross-hatched areas R exceeds 10,000/sec. See text for further discussion

drawn. Much of the diagram remains conjectural, of course.

The complete intensity-structure of the trapped radiation regions may be more complex than that shown in Fig. 5; but we believe that it cannot be essentially simpler. Inasmuch as the features of the diagram due to 1958ε observations persisted through a two-month period during July–August–September 1958, we regard the outer zone as well as the inner one as a quasi-permanent feature, although the *Pioneer III* observations would not in themselves permit such a conclusion, since they were made within a single two-day period. With detectors of lesser or greater stopping power, the structure of the radiation zones may be found to be different; but results with the diversity of detectors in satellite 1958ε suggest that it will be similar for a wide range of stopping powers.

It now appears that the outer zone is the one more intimately related to usual, high-latitude auroræ.

It will not, of course, be surprising if the level of intensity of trapped radiation and indeed the structure of the entire radiation region are found to be strongly dependent on solar activity, averaged over an appropriate mean trapping time (for example, several weeks or months). In our present view, gross fluctuations on an eleven-year cycle would be expected. Details of the intensity-structure may fluctuate, of course, on a much shorter time scale.

The *Pioneer III* observations give no information on the range spectrum of the trapped radiation. But as previously reported[7,8], the 1958ε observations show that the radiation at high altitudes near the geomagnetic equator is more penetrating than that in high latitudes. This fact together with Fig. 5 encourages one to conjecture that the inner and outer zones may have different physical origins; for example, the outer one due to solar plasma and the inner one due to cosmic ray albedo decay products. Another possibility may be selective radial diffusion of particles in the inhomogeneous geomagnetic field according to their respective magnetic rigidities[9] or according to a combination of the sign of their electrical charge and their magnetic rigidity.

It is obviously of great importance to learn the respective energy spectra of protons and of electrons throughout the trapping region. In the light of the above conjectures, special interest is attached to learning the spectral differences, if any, between the radiation in the inner zone and that in the outer zone.

A satellite in a pole-to-pole orbit of high eccentricity is desirable in order to plot the structure of the radiation region to a good level of satisfaction and to follow its temporal changes. Another attack on the matter can be visualized by using a 'vertical' probe (ideally in the plane of the geomagnetic equator) equipped to measure at each point along its trajectory the angular distribution and energy spectra of electrons and protons separately. Such information is adequate in principle to plot the entire region if one makes full use of the theory of the motion of charged particles in the (approximately known) geomagnetic field.

Effective Radial Extent of the Geomagnetic Field

In the range $27{,}000 \lesssim \rho \lesssim 37{,}000$ km., where ρ denotes the radial distance from the centre of the Earth, the counting rate R is accurately represented by an equation of the form:

$$R \sim \exp(-\rho/2300) \qquad (5)$$

Beyond 37,000 km. the counting rate continues to decline smoothly though progressively less rapidly with increasing ρ. Beyond some 64,000 km. ($\rho = 10$ times the radius of the Earth, ρ_E) the rate of decline becomes very much less (Fig. 2).

Although there is nowhere an abrupt cut-off, it appears reasonable, from Fig. 2, to consider the outer limit of the region of trapped radiation to be at $\rho/\rho_E = 10$. At this radial distance the intensity of the trapped radiation, at least as measured with the present equipment, becomes less than the interplanetary cosmic-ray intensity (see the following section). The following quantities are pertinent to a discussion of the significance of this result:

At $\rho/\rho_E = 10$, (*a*) the strength of the idealized dipole field of the Earth is $B = 3{\cdot}1 \times 10^{-4}$ gauss; (*b*) the corresponding magnetic energy density is $B^2/8\pi = 3{\cdot}8 \times 10^{-9}$ ergs/cm.^{3}; (*c*) the maximum magnetic rigidity which a charged particle can have and still be trapped in an idealized dipole field if it is moving in the least favourable trajectory is $pc/ze = 1 \times 10^8$ V. (Störmer cut-off). This magnetic rigidity characterizes a proton of 5×10^6 eV. kinetic energy or an electron of 100×10^6 eV.

It may also be noted that: (*a*) the shielding of our Geiger–Müller tube is such as to stop 30×10^6 eV. protons or $2{\cdot}2 \times 10^6$ eV. electrons; (*b*) the Störmer cut-off at $\rho/\rho_E = 6$ corresponds to the proton energy just sufficient to penetrate the shielding of the Geiger–Müller tube.

Consideration of the observed results in conjunction with these facts leads us to conclude that probably neither of the two straightforward criteria for loss of trapping effectiveness, that is, the Störmer criterion, or the volume density of particle kinetic energy being comparable to the magnetic energy density, is the dominant one.

Disturbance of the idealized dipole field of the Earth is progressively easier at greater radial distance. It is commonly supposed that the effective radial extent of the geomagnetic field is determined by the prevailing interplanetary field. In the circumstances of the flight of *Pioneer III* it appears that the interplanetary field may have been as great as 3×10^{-4} gauss, though perhaps a field weaker by an order of magnitude would suffice.

A more quantitative view of the steady decline of the trapped intensity beyond $\rho/\rho_E \sim 3\cdot5$ may indicate that the loss of trapped particles is progressively more probable with greater distance due to intermittent perturbations (from solar gas) the effect of which is, on the average, greater at greater radial distances.

It is of interest and perhaps of significance to note that a dipole line of force through $\rho/\rho_E = 4\cdot8$ on the geomagnetic equator reaches the Earth's surface at a geomagnetic latitude of 63°, the approximate lower latitude boundary of the usual zone of maximum auroral activity; and one through $\rho/\rho_E = 10$, at 71·5°, the approximate higher latitude boundary.

Interplanetary Value of Cosmic Ray Intensity

Beyond 10 Earth radii, the counting rate of the 302 declines very gradually and appears to have reached an asymptotic value of 2·25 counts/sec. at the outermost point of the observations, namely, 17 Earth radii. It is not known whether or not there remains a significant contribution from a residuum of geomagnetically trapped radiation or from soft, interplanetary radiations. On the basis of the observed radial dependence of counting rate it is quite likely that the residuum of trapped radiation contributes negligibly at $\rho/\rho_E = 17$.

The Earth's dense atmospheric shell subtends a solid angle of 10^{-3} of a sphere at the position of the apparatus at $\rho/\rho_E = 17$. Hence the Earth is a negligible source of high-energy escaping albedo and is also a negligible scattering and absorbing body for high-energy primary cosmic rays.

The idealized Störmer cut-off at this radius is $0\cdot03 \times 10^9$ V. magnetic rigidity, corresponding to kinetic energies of 5×10^5 eV. for protons or 3×10^7 eV. for electrons.

Thus, subject to the above discussion, we find:

$$J_0(\text{interplanetary}) = 3\cdot6 \pm 0\cdot8 \ (\text{cm.}^2/\text{sec.})^{-1} \qquad (6)$$

Almost the entire uncertainty in this preliminary result is due to the uncertainty in the absolute geometrical factor (see section on transmission of data). No previous measurement of J_0 at a point remote from the Earth has been made. The significance of this result will be discussed in a later article.

Fluctuations in Counting Rate Beyond 10 Earth Radii

The counting rate of the 302 tube did not fluctuate beyond statistical expectations during the some 12 hr. of observations at radial distances greater than 10 Earth radii: and in fact, its rate at lesser distances was a remarkably smooth function of time (or of spatial position). This appears to mean either that no 'blobs' of interplanetary plasma were encountered during this observing period or that any such blobs did not contain sufficiently energetic radiation to produce a significant contribution to the counting rate. No critical assessment of the prevailing solar-terrestrial situation has been made as yet. The preliminary Climax report indicates mild to moderate solar activity.

Biological Exposure-Levels

If there is an omnidirectional intensity J_0 of charged particles at a point, then the rate of ionization produced in a test quantity of air there may be measured in roentgens per hour. The equivalence is:

$$(\text{roentgens/hr.}) = 1\cdot25 \times 10^{-4}\,\overline{(S/S_m)}J_0 \qquad (7)$$

where J_0 is in particles/cm.² sec. and $\overline{(S/S_m)}$ is the mean ratio of specific ionization of the particles to the minimum value for a fast, singly charged particle (1·8 MeV./(gm./cm.²)). The omnidirectional intensity measured by *Pioneer III*, if attributed to charged particles only, is given by:

$$J_0 = \frac{R}{(0\cdot75)(0\cdot83)} = 1\cdot6\,R \qquad (8)$$

where R in sec.$^{-1}$ is the true counting rate as plotted in Figs. 1, 2, 3, 4 and 5.

For practical use of Figs. 1, 2, 3, 4 and 5, one may combine equations (7) and (8) to give:

$$(\text{roentgens/hr.}) = 2\cdot0 \times 10^{-4}\,\overline{(S/S_m)}R \qquad (9)$$

For example, the maximum observed exposure-levels in the hearts of the two radiation zones are in the range 5–10 roentgens/hr. if the response of the detector is due only to direct penetrations by electrons. If its response is due only to protons having a rapidly falling spectrum in the tens of MeV. range, as another example, $\overline{(S/S_m)}$ is of the order of 10–20 and the exposure would be in the range of 50–100 roentgens/hr.

It is, of course, understood that these estimates are valid only for the shielding actually used in this experiment (see section on radiation detectors). It is still not known how absorbable the radiation is at various points in space.

Discussion of exposure-levels if the response of the detector is due only to bremsstrahlung from electrons (of energy less than 2·2 MeV.) stopped in the apparatus will be given in a later report.

In addition to the acknowledgments in the body of this article, we should like to mention the many fruitful conversations with Dr. Ernest C. Ray and with Messrs. Carl E. McIlwain and George H. Ludwig of this laboratory.

The engineering of the payload of *Pioneer III* was supervised by Mr. Dan Schneiderman of the Jet Propulsion Laboratory. Support for the State University of Iowa portion of the experimental work and the analysis of observations was provided in part by a sub-contract with the Jet Propulsion Laboratory.

[1] Van Allen, J. A., paper presented at joint meeting of National Academy of Sciences and American Physical Society on May 1, 1958.

[2] Van Allen, J. A., Ludwig, G. H., Ray, E. C., and McIlwain, C. E., "Observation of High Intensity Radiation by Satellites 1958 Alpha and Gamma", I.G.Y. Satellite Report Series No. 3: "Some Preliminary Reports of Experiments in Satellites 1958 Alpha and Gamma", pp. 73–92 (U.S. Nat. Acad. Sci., 1958).

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NEWS and VIEWS

Prof. C. T. R. Wilson, C.H., F.R.S.

C. T. R. Wilson celebrates his ninetieth birthday on February 14 at his home in Carlops, close to his place of birth, the farmhouse of Crosshouse in the Pentland Hills near Edinburgh. It is now almost half a century since he exposed the air in his cloud chamber to X-rays "with little expectation of success, and in making an expansion of the proper magnitude for condensation on the ions while the air was exposed to the rays, I was delighted to see the cloud chamber filled with little wisps and threads of clouds—the tracks of electrons, ejected by the action of the rays". Here was the instrument which, suitably developed and adapted, was to provide photographs giving an almost complete record of the development of nuclear physics during the succeeding thirty years. The disintegration of nitrogen by alpha-particles was first photographed by Blackett in 1925, and the first example of disintegration produced by neutrons was similarly obtained by Feather in 1932. The power of the Wilson method was greatly extended and its application to cosmic-ray studies facilitated when Blackett devised the automatic control of the chamber by the rays. First evidence for the positron had been discovered by Anderson in 1932, using the method of random expansions; Blackett and Occhialini, using the counter-controlled chamber in the following year, were quickly able to obtain massive support for Anderson's discovery. In 1937 Anderson and Neddermeyer obtained evidence for mesons in cosmic rays from cloud-chamber photographs. While the simpler technique of using fine-grain photographic emulsions for recording nuclear reactions has superseded the cloud chamber, especially in the investigation of the tracks of heavy particles, there are many reactions requiring controlled observation which can be studied only by the Wilson method.

The world-wide recognition that the association of his name with the cloud chamber has brought to 'C. T. R.' has tended to obscure the fact that his investigations of atmospheric electricity and of the electric fields of thunderstorms have provided the basis of our knowledge in this field. Only a year or two ago, he published a paper on the mechanism of the generation of electric charge in thunderclouds in the *Proceedings of the Royal Society*, of which he is senior Fellow. It is perhaps not generally known that the whole of Wilson's scientific work developed out of certain experiences on Ben Nevis—the cloud chamber from his observations in 1894 of glories seen from the edge of the summit precipice overlooking the great corrie, and the thunderstorm work from feeling the effects of sudden changes in the electric field of a thundercloud while standing on the summit of Carn Mor Dearg in 1895. 'C. T. R.' still retains his interest in clouds, and takes every opportunity of flying into them by joining members of the class of meteorology at the University of Edinburgh in flights arranged for them by the Royal Air Force. Some of his colleagues from Sidney Sussex College and former students at Cambridge are to lunch with the Wilson family in the Allan Ramsay Inn at Carlops on Tuesday, February 17.

Rumford Premium of the American Academy of Arts and Sciences: Prof. G. Wald

The Rumford Premium for 1959 of the American Academy of Arts and Sciences has been awarded to Prof. George Wald, of Harvard University, for his work on the biochemical basis of vision. In addition to the traditional gold and silver medals, this award, established by the Academy 163 years ago, carries a premium of 5,000 dollars to the recipient. The formal presentation will be made at a meeting of the Academy on March 11, 1959. Prof, Wald was born in New York City in 1906. He graduated in New York University in 1927 and was awarded his doctorate by Columbia University in 1932. As a graduate student, he came under the influence of Prof. Selig Hecht, who played an important part in Dr. Wald's subsequent career. During 1932–34 he was a National Research Council Fellow in Berlin, Heidelberg, Zurich and Chicago. He went to Harvard as a tutor in biochemical sciences in 1934 and became professor of biology in 1948. His research has centred on the chemistry of the visual process, with particular reference to the chemical changes which occur in the rods and cones of the eye following excitation by light quanta. Recent work from his laboratory in this field is described in this issue of *Nature*, p. 442.

Royal Society Committee on Scientific Research in Schools

In order to assist schoolteachers who wish to pursue scientific research the Royal Society established a Committtee on Scientific Research in Schools in March 1957. The following were appointed members: for the Royal Society, Sir Lindor Brown (chairman), Dr. F. P. Bowden, Sir Edward Salisbury; for the Science Masters' Association: Mr. W. Ashhurst, Mr. R. H. Dyball, Mr. M. C. Nokes. Later Dr. C. G. Williams was appointed as an additional member. Dr. Williams is director and general manager of Shell Research, Ltd.; the Committee has been greatly encouraged and assisted by this company, which in 1956 took up this question and is at present supporting research work in nine schools. A statement about the Committee and its aims was circulated to the headmasters and headmistresses of 1,383 schools in the British Isles at the end of 1957. Requests for advice have been received from fifty-seven schoolmasters and mistresses, and twelve research projects are at present being undertaken with the assistance of the Committee, in addition to those previously initiated by Shell Research, Ltd. Twenty-one additional research projects are at present under consideration. The Science Museum Library has agreed to lend periodicals to those carrying out work under the advice of the Committee. Considerable assistance in making literature available has also been given by various university departments and a scheme is being operated by the Royal Institution whereby its library may be used by schoolmasters and mistresses for a small subscription. All research projects with which the Committee is dealing have been scrutinized by Fellows of the Royal Society or by others who have agreed to act as advisers. In a number of cases, Fellows have lent apparatus from their own departments for particular projects. The response to this scheme has been very encouraging and consideration is now being given to placing under the ægis of the Committee the research projects at present assisted by Shell Research, Ltd. The Committee looks forward both to receiving further requests from schools and to the continued valuable support of Fellows of the Royal Society and others in acting as advisers and assisting in the extension of its activities.

Nuclear Reactors on a Commercial Basis

IN reply to a question in the House of Commons on February 5, the Prime Minister stated that the United Kingdom Euratom Agreement was signed on February 4 and the text was published as a White Paper. The prospects for sales of British reactors in the Euratom market, he said, will depend on commercial considerations; but the established achievements of the Calder Hall prototypes and the developments incorporated in the later commercial designs now available for export should give British manufacturers a good prospect of success in Euratom countries. Mr. Macmillan agreed that the ability of the United States to supply fuel for the first year free of charge made it difficult to compete in contracts for power stations, although he believes that Britain is further advanced in this field than the United States are. It is, however, an expanding field and besides the Euratom Agreement Britain has already made separate agreements with individual countries, and this has resulted in an arrangement for a British plant to be erected in Italy.

Fog Dispersal

THE Parliamentary Secretary to the Ministry of Transport and Civil Aviation stated in reply to a question in the House of Commons on February 4 that research carried out by the Ministry of Supply indicates that the most promising method of fog dispersal is the thermal one known as F.I.D.O. His Ministry is collaborating with the Ministry of Supply in tests with a new type of F.I.D.O. installed at an R.A.F. aerodrome. This is a high-pressure system with a new type of burner which, it is hoped, will be more economical in operation. The old system was very expensive both to install and to operate. Although F.I.D.O. could provide a clear area, there would still remain the problem of the wall of fog which the aircraft would have to penetrate first. It is considered unlikely that automatic landing equipment would provide a complete solution to the problem.

Electrical Instrument Test Service

THE British Scientific Instrument Research Association has established an electrical instrument test service at its laboratories in Chislehurst, Kent. Although originally set up at the request of members of the Association, the service is now available to other firms and organizations. It is operated under the supervision of the National Physical Laboratory and will test and issue certificates for instruments up to 'Precision Grade' accuracy. Calibration of d.c. meters between 1 mV. and 500 V. and between 2 μamp. and 2 amp. can be undertaken immediately. In the near future the latter range is to be extended to 25 amp., and the calibration of a.c. instruments over the ranges 1–500 V. and 10 m.amp.–25 amp. will be undertaken. Charges for the service will be appreciably less than the cost of National Physical Laboratory certification. Further information can be obtained from the Director of Research, British Scientific Instrument Research Association, South Hill, Chislehurst, Kent.

Bird Migration

IN addition to its established quarterly journal, *Bird Study*, the British Trust for Ornithology has launched a half-yearly publication entitled *Bird Migration* (1, No. 1; December 1958. iv+40 pp. 2*s*. 6*d*.). This is related to the Trust's recently adopted scheme for co-ordinating the activities of the score of bird observatories which now form a remarkable network around the British coasts, and for ensuring the complete availability and summary publication of the data collected. A grant made for five years by the Nuffield Foundation has enabled the Trust to appoint a whole-time migration research officer, Mr. Kenneth Williamson, who edits the new journal. This first issue includes a series of summary reports from the individual observatories on the autumn migration of 1958, followed by an editorial review of the more notable aspects of the movements as a whole. The season is shown to have been an interesting one in several respects, and this convenient account of it—accompanied by weather maps where necessary—is welcome. The value over a sequence of years should be cumulative.

Plastics Abstracts

PLASTICS INVESTIGATIONS is publishing a new weekly journal, *Plastics Abstracts*, which aims to give a comprehensive abstracting service covering British patent specifications and periodical articles dealing with the science, technology and applications of plastics. A valuable feature of these abstracts is the promptness with which they are published—normally one week after publication of the original patent specifications, and within two weeks of publication of the periodical articles. The preparation of this journal is based on a complete weekly scrutiny of British patent specifications and the regular examination of about 250 periodicals. Detailed author, patent and subject indexes will be published annually, and subscribers' requests for specific information contained in the current year's abstracts will be answered free of charge. *Plastics Abstracts* is obtainable from the publishers, Plastics Investigations, 23 Canonsfield Road, Welwyn, Hertfordshire. The subscription rates are £25 annually including postage, or £35 by air-mail; single copies can be obtained for 10*s*., or 14*s*. by air-mail.

Drilling a Borehole to the Earth's Mantle

PROF. HANS PETTERSSON has recently written an article in the *Stockholms-Tidningen* about drilling a deep hole to the Mohorovičić discontinuity between the Earth's mantle and the surface rocks, in which he refers to the article by Dr. T. F. Gaskell in *Nature* of September 13, p. 692, which discussed this project. Prof. Pettersson reminds his readers that the only knowledge of the depth of the base of the Earth's crustal rocks is that obtained from the study of earthquakes. These observations, however, do not allow one to say with certainty what is the rock material which constitutes the Earth's mantle. It is possible that some of the research concerned with the planets and the Moon may give useful clues to what material exists inside the Earth, but there is a strong argument for spending part of the limited amount of money available for research on the more direct approach of drilling down into the Earth. As Dr. Gaskell pointed out, it is only the cost of drilling to the Mohorovičić discontinuity that is holding the project back: it would be possible from a technical point of view to start to-day. This is especially true of the proposal to drill through the sediments that cover the floor of the deep oceans.

Prof. Pettersson is, of course, one of the world's experts in the deep-sea sediments, but even with his best corers he has managed to penetrate only the top 20 m. of the sea-bed. He points out how important the complete column of deep-ocean sediments will be, because they must surely contain the history of the past geological behaviour of the Earth. Prof. Pettersson does not mention the United States Navy research project which has been set up to look into the economics and desirability of the Mohorovičić and deep-ocean sediments projects which were suggested at the Toronto International Geophysical Meeting in 1957, nor does he say anything about the rumoured Russian attempts to be first in this field.

Regional Museum Council

For many years the Museums Association has endeavoured to obtain some form of assistance from the Government for the smaller museums in Britain. It is well known that in several instances the position is desperate, and valuable material is being lost for want of proper conservation. During the past eighteen months a committee of inquiry in the south-west of England has accumulated facts, and at a meeting at Taunton on January 8 presented a report on the present position of museums in its area together with a series of maps indicating the distribution and size of the collections in the fields of archæology, applied art, fine art, botany, folk-lore, furniture, geology, numismatics and zoology. Dr. W. E. Swinton, president of the Museums Association, was in the chair for this, what may well prove to be a historic, occasion.

After full consideration of the report, it was decided to form a Regional Museum Council. The scope of this Council will include the counties of Bristol, Cornwall, Devon, Dorset, Gloucestershire, Somerset and Wiltshire and the town of Newport in Monmouthshire, while its objects will be to promote co-operation, improve technical facilities and to grant financial assistance to museums and art galleries within the region. The Council will consist of twenty-two members, and it has power to co-opt and make provision for alternate members. Sir John Hobhouse has been appointed chairman and Mr. F. J. Stott vice-chairman of the Council. The outcome of this initial effort on the part of the museums of the south-west of England will be awaited with interest, for if successful it will probably be followed by other regional councils in various parts of the British Isles.

United States Atomic Energy Commission Training Courses

The U.S. Atomic Energy Commission has made grants totalling 2,264,965 dollars to forty-one universities and colleges in the United States for the purchase of laboratory equipment needed to expand their nuclear educational programmes. These grants include funds to seven engineering institutions, namely, Kansas State College and the Universities of Illinois, Maryland, Texas, Washington, West Virginia and Wisconsin, for the purchase of teaching reactors. The seven reactor grants bring to thirty the total number of teaching reactors in operation or to be constructed in American universities with the help of Commission grants.

The U.S. Atomic Energy Commission has also started a new programme of assistance to colleges and universities in the United States for education and training in radioisotope principles and technology. Direct financial assistance is to be given in obtaining demonstration apparatus, student laboratory equipment and training aids needed to offer adequate laboratory course-work in radioisotope technology.

Pyrite Granules and Fossil Micro-organisms

Small spheres, usually less than 50μ across, composed of tightly packed pyrite crystals, are common in sedimentary rocks. They have been noted in rocks of both marine and freshwater origin, from those of the Cambrian to present-day sediments, and have previously usually been considered to be of inorganic origin or to have been associated with the activities of sulphur bacteria. L. G. Lowe has recently shown that spheres of this kind from certain beds of the Scottish Lower Carboniferous oil shale group enclose microfossils of a hitherto unknown group (*Quart. J. Geol. Soc.*, 113, 429; 1958). The two new monotypic genera, *Pyritosphaera* and *Pyritella*, are both rounded in form and apparently multicellular, the surface of the former being covered with radial spines. The affinities of these genera cannot at present be defined, but they are evidently not bacteria. It is suggested that during their life-time the organisms generated hydrogen sulphide as a by-product of the anaerobic decomposition of sulphur compounds (probably sulphates) and that the gas reacted with iron ions to precipitate iron sulphide on their surfaces. It remains to be seen whether future studies will reveal a range of genera and species capable of being used as stratigraphic or environmental indices, as has been the case with so many other types of microfossils in recent years, but it seems clear that where found *Pyritosphaera* and *Pyritella* demonstrate stagnant conditions at the time the containing sediment was formed.

Morhana Parar

The issue of *Man* of last October contains an interesting article by Dr. Allchin which deals with a number of deep rock shelters in India, called Morhana Parar, which have yielded numerous pigmy tools, and the walls and ceilings of which have been painted. The sites, near the village of Bhainswar, some 42 miles south of Mirzapur on the Great Deccan Road, had been investigated as long ago as 1880 by A. C. Carlleyle, who died before he had been able to deal with his discoveries, and the caves had been forgotten. Some of the 'loot', however, seems to have found its way into several European museums and collections. Now the sites have been rediscovered and studied by Dr. Allchin. The paintings consist of hunting and dancing scenes, chariots and animals. It is to be presumed that the makers of the pigmy tools were the painters.

Disposal of Radioactive Waste

A detailed study of the microbiology and water circulation in the Black Sea by A. E. Kriss (*Priroda*, 6, 43; 1958) and the water circulation in oceans by V. G. Bogorov and E. M. Kreps (*Priroda*, 9, 45; 1958) show that the vertical circulation of sea and ocean waters would not allow the disposal of radioactive waste in their deeper zones (see *Nature*, 182, 563 ; 1958).

D.S.I.R. : Longer-term Grants for Special Researches

LONGER-TERM grants for special researches will be awarded by the Department of Scientific and Industrial Research in future. These grants—which have normally been limited to a maximum of five years—may now be awarded for an initial period of up to seven years with the possibility of continuing support for a further ten years. When fully established, the support for these researches will be transferred from the Department to a university. The Department is therefore willing to support for longer periods outstanding university investigators embarking on promising researches for which their universities are unable to make adequate provision. The first closing-date for applications is March 1. Further information can be obtained from the Department of Scientific and Industrial Research, 5–11 Regent Street, London, S.W.1.

University News : Birmingham

THE following appointments have been announced in the University of Birmingham: G. S. Pittaway to be lecturer in chemical engineering ; Dr. W. T. Roberts to be lecturer in industrial metallurgy ; Dr. A. L. Haigh to be lecturer in physiology.

Durham

PROF. E. LEDERER of the Institut de Biologie Physico-Chimique, 13 Rue Pierre Curie, Paris, will visit King's College in the University of Durham, Newcastle upon Tyne, during March 3–21 and for a further period after Easter.

University College of Rhodesia and Nyasaland

MR. D. J. EVE has been appointed lecturer in inorganic and physical chemistry.

Announcements

PROF. N. F. MOTT, Cavendish professor of experimental physics in the University of Cambridge, has been elected Master of Gonville and Caius College, Cambridge, in succession to Sir James Chadwick, who is retiring.

MR. W. S. ELLIOTT has been appointed managing director of IBM World Trade Laboratories (Great Britain), Ltd., a new subsidiary of IBM World Trade Laboratories Corporation of New York. At present the Laboratories are at Hursley House, near Winchester in Hampshire, but it is planned to erect a new laboratory in the Southampton area. Research and development are being undertaken in the field of electronic data processing and computing.

A RESIDENTIAL working conference on Automatic Programming of Digital Computers will be held in the Department of Mathematics, Brighton Technical College, during April 1–3, under the direction of Dr. A. D. Booth. Further particulars and forms of application can be obtained from the Registrar, Brighton Technical College, Richmond Terrace, Brighton.

THE Stress Analysis Group of the Institute of Physics, in collaboration with the Instituut T.N.O., is organizing a conference to be held at the Technische Hogeschool, Delft, during March 31–April 4, at which 55 papers to be distributed beforehand will be discussed. The conference is open to all who are interested : details of the programme and registration forms can be obtained from the Assistant Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1.

THE Parasitology Group of the Institute of Biology is holding its spring meeting at the University of Edinburgh during March 19–22. Twenty-five communications and several laboratory exhibitions have been selected ; the proceedings of the meeting will not be published. Those wishing to attend the meeting should register before February 28. Further information on the programme can be obtained from Miss June Mahon, Bedford College, Regent's Park, London, N.W.1.

Two symposia, on "Water and Woodlands" and on "Lysimeters", respectively, organized by the International Association of Scientific Hydrology will be held at Hannoversch–Münden, near Kassel, in Germany, during September 8–13. Intending contributors should submit summaries to the Assistant Secretary, The Royal Society, Burlington House, Piccadilly, London, W.1, from whom further information can be obtained. Completed papers must be submitted by the middle of April.

THE eleventh Technical Exhibition of the Oil and Colour Chemists' Association will be held in the New Hall of the Royal Horticultural Society at Greycoat and Elverton Streets, London, S.W.1, during March 17–19. The theme of the Exhibition will be the presentation of technical advances in those industries supplying the paint, varnish, printing ink, linoleum and other allied industries. The technical advances may relate to new products, new knowledge relating to existing products and their uses or, in suitable cases, existing knowledge which is not generally available in the consuming industries. Admission is free for both members and visitors. Further information can be obtained from the general secretary, Mr. R. H. Hamblin, Memorial Hall, Farringdon Street, London, E.C.4.

THE Acoustics Group of the Physical Society is sponsoring two symposia dealing with the problem of noise and vibration. The first, at 2.15 p.m. on March 24 in the Physics Department, Imperial College of Science and Technology, London, on "Recent Studies of Noise Problems", will survey recent work on the measurement and effects of noise. It is open to all without formality. The second is a one-day meeting on April 7 in the University of Southampton. Entitled "New Techniques in the Analysis of Noise and Vibration", it will include contributions on aspects of the use of correlation techniques, of digital computers for data processing and analysis, and on general applications of statistical communication theory. It is a joint meeting with the Institute of Physics. Further information can be obtained from D. M. A. Mercer, Physics Department, University of Southampton.

ERRATUM. In the communication by M. V. Carter entitled "Chemical Destruction of Mature Perithecia of *Mycosphaerella pinodes*", in *Nature* of January 17, p. 162, a line of description was omitted from the headings of columns 3–7 in Table 2. These headings, which refer to concentrations of pentachlorophenol, should read 0·1, 0·2, 0·5, 1·0 and 2·0 per cent, respectively.

LEGUMES IN AFRICAN AGRICULTURE

A TECHNICAL meeting on "Legumes in Agriculture and Human Nutrition" was held recently at Bukavu, Belgian Congo, under the joint auspices of the Food and Agriculture Organization of the United Nations and the Commission for Technical Co-operation in Africa South of the Sahara. Delegates attended from the Belgian Congo, French territories in Africa south of the Sahara, Nigeria, Federation of Rhodesia and Nyasaland, Northern Rhodesia, Southern Rhodesia and Portuguese territories in Africa.

The Agricultural Section at this meeting, under the chairmanship of Mr. A. Angladette, of the Office de la Recherche Scientifique et Technique Outre-Mer, had a very full agenda since attention had to be given to the cultivation of legumes for human food (grain or green vegetable), grazing and fodder production, as well as the improvement of soil fertility through the cultivation of these crops in rotations or as green manures.

Statistics with regard to acreages and production of grain legumes are entirely inadequate; but a general trend may be seen towards increased cultivation of cash crops and the progressive elimination of grain legumes, with the exception of the groundnut where it is grown commercially for export or for oil extraction. Grain legumes may be grown in the garden plot close to the house, in association with other crops and on soils rich in organic matter, or in the 'outfield' in the cropping phase of shifting cultivation.

The most widespread leguminous grain crops at the present time are groundnuts and cowpeas (*Vigna sinensis*), with the haricot bean (*Phaseolus vulgaris*) at the higher altitudes. Interest in *Voandzeia* and the acreage of this plant are decreasing. The greatest need for grain legumes is, however, in the low-lying wet tropics where there are no livestock or grain crops, and the people live on starchy foods such as cassava.

The delegates to the Nutrition and Agricultural Sections of the meeting recognized that some twenty African grain legumes could be regarded as of primary importance from both a nutritional and an agricultural point of view, and that these therefore represented a good basis for future development. The meeting, and particularly the delegates from the Belgian Congo, nevertheless stressed the need for a thorough search in local floras for new legumes for use as food, fodder, shade and cover plants and green manure crops. Any new material which might be found should be the object of study by the plant breeders, who should concern themselves with both quantity and quality (higher protein content and acceptable palatability). Attention should also be given to the production of varieties adapted to methods of cultivation and harvesting involving draught animals or powered machinery.

It would be desirable to facilitate the interchange of seeds of present or new types of plants between the different parts of the region. Seed samples should always be accompanied by adequate data regarding the ecological conditions of the station of origin or place of collection, and also, if possible, by a herbarium specimen for checking purposes. The need to establish herbaria for species and cultivars was also stressed.

The extent of cultivation of legumes for grazing or cut fodder varies considerably as between the different territories. Considerable success was reported in the sod-seeding of *Stylosanthes gracilis* in the existing pastures in the savannah zone. The pigeon pea (*Cajanus cajan*) is grown as spaced hedges in pure Rhodes grass (*Chloris gayana*) pastures in Southern Rhodesia. *Centrosema pubescens* and *Pueraria javanica* are promising for the wetter areas, with *Stizolobium deeringianum* as cut fodder. An important factor limiting the greater use of grazing and fodder legumes is the lack of adequate seed supplies. The meeting, therefore, stressed the need for promoting greater production and better distribution of seeds of legumes adapted to the various regions, supported by a service designed to control quality. Research on seed biology (hard seeds, viability, etc.) is also necessary.

It was agreed that the foremost problem is at present to grow better the legumes already available. There are wide differences between the yields obtained by the average cultivator and those which may be obtained with improved methods of cultivation. Correct and adequate mineral nutrition and an optimal legume/*Rhizobium* relationship are among the primary factors to be considered in this connexion. The policy of fitting the soil to the legume is much more difficult in African peasant agriculture than under more intensive systems of farming. It is also desirable to fit the legume to the soil by the selection, for example, of varieties adapted to either high or low levels of soil fertility. Economic considerations are important in this respect.

On these aspects the meeting recommended that more attention should be paid to fundamental research on legume nutrition and on the factors affecting the development of their associated *Rhizobia*. Workers in Africa south of the Sahara have requested the United Nations Food and Agriculture Organization to publish and keep up to date a world list of scientific institutes pursuing studies on *Rhizobia*, as well as a catalogue of the strains that these institutes have available.

Many examples were quoted of the serious economic losses caused by fungous diseases and insect pests both in the field and in the store. In the latter connexion, it is desirable to evolve cheap methods of grain storage for peasant farmers; for example, oil drums with screw tops into which beans could be placed when quite dry, and in which any beetles or other insects would be smothered. It is desirable that countries should publish a list of the pests and diseases of legumes and evaluate the economic importance of the losses they cause, carry out studies of the biology of the most important ones, develop methods for their prevention and control, and prevent the introduction of pests and diseases from other countries or territories by observing international phytosanitary regulations.

It is obvious that legumes can contribute greatly to the improvement of human and animal nutrition and to the fertility of the soil in Africa south of the Sahara, as in other parts of the world. Many questions, however, remain unanswered, and the need now is for a well co-ordinated programme of research, dealing with as many aspects as possible but avoiding duplication of effort. The delegates to this meeting repeatedly stressed the need for governments to provide more funds and facilities for this research. They also indicated to the organizations sponsoring this meeting that regional conferences or special study groups could with advantage give attention in due course to the correct utilization and development of the grazing and fodder resources of Africa south of the Sahara, and also to the specific problems of mineral nutrition in relation to legume *Rhizobia*, and the incidence, biology and control of pests and diseases of African legumes.

A report of this meeting will be available shortly in English, French and Spanish.

R. O. Whyte
T. R. G. Moir

GELATINE AND GLUE RESEARCH

The sixteenth meeting of the Research Panel of the British Gelatine and Glue Research Association was held on December 12, with Mr. S. G. Hudson (Richard Hodgson and Sons, Ltd.) in the chair. Three papers were presented, each by members of the staff of the Association, and were discussed by an audience representative of both the industrial and academic aspects of the work.

The first paper, on "Solubilized Collagen", by Dr. A. Courts and Dr. G. Stainsby, was presented by Dr. Courts, who mentioned briefly the preparation of soluble collagen, especially from the skin and other collagenous tissues of young animals. He then described the modification of the corresponding tissues of adult animals, by cold alkaline pretreatment, to enable the usual solvents for soluble collagen (citric acid and citrate buffers) to extract substantial fractions of the pretreated collagen in the cold. The solutions obtained showed qualitatively similar behaviour to soluble collagen, such as high viscosity in very dilute solution, precipitation in fibrous form on dialysis against distilled water, or on the addition of salt, and conversion to gelatin on warming. Quantitatively, the intrinsic viscosity, while varying to some extent according to raw material and mode of pretreatment, was in agreement with the results of Doty and Nishihara[1] for soluble collagen from calf-skin. Ossein, the demineralized organic component of bone, gave, in a typical experiment, a 30 per cent conversion to solubilized collagen, and there was no reason to regard this as the ultimate limit possible. Sinew and skin were more difficult to convert, but the same general behaviour was observed. The pretreatment processes, if not in detail reversing the process by which collagen is laid down in insoluble form, leave fragments which may have structural significance for the original tissue. The temperature of conversion from the solubilized collagen to gelatin in citrate buffer at *p*H 3·7 was in the region of 30° C., which is lower than that reported for soluble collagen from calf-skin. There is probably only a slight difference in temperature of conversion at neutral *p*H values. The change in optical rotation was measured by Dr. A. Todd, and gave values of specific rotation $[\alpha]_D$ for the soluble collagen and derived gelatin close to those of Doty and Nishihara[1], although confirming the lower conversion temperature of 30° C. noted above.

Mr. A. A. Leach read the second paper, on "The Examination of Gelatine by Passage through Amberlite Resins of the 'I.R.C. 50' (Carboxylic) Type". The paper consisted of a critical examination of the separation of gelatin into two components, by *XE*.97 resin, reported by Mr. G. Russell (Ilford, Ltd.) at the fourteenth meeting of the Research Panel and in a short account in *Nature*[2]. In a typical experiment, a small quantity of gelatine was placed at the top of a resin column previously equilibrated to the required *p*H. Buffer solution at the same *p*H was then passed through the column, fractions collected, and the concentration of protein estimated by the Lowry method, or collected for further analysis. To obtain sufficient of any minor components, large columns of resin were used. It was shown that from *p*H 3 to 5·25 a very small proportion (about 0·3 per cent) of the gelatine used (laboratory sample 127) passed through the column with negligible adsorption, while the remainder was firmly adsorbed as long as the column was not overloaded. Amino-acid analysis of the small eluted fraction gave only a very low content of hydroxyproline, little glycine or proline, and high valine, leucine, *iso*leucine, tyrosine, threonine and aspartic acid compared with the whole gelatine. The analysis is similar to that of Maron[3] for an impurity isolated by adsorption on charcoal.

At higher *p*H, increasing amounts of gelatine 127 are separated in the first peak, while retaining a sharp separation from the remaining adsorbed gelatine. By *p*H 6, 93 per cent of the gelatine was eluted. The percentage eluted could also be increased by overloading a column. Chemical analysis showed that, as soon as several per cent of the gelatine is contained in the first peak, either by overloading or by raising the *p*H, the bulk of the eluted fraction is a substance of gelatin type containing hydroxyproline, with a composition almost identical with the parent gelatin. There was evidence that molecular weight played some part in the separation and a possibility that minor differences in amino-acid composition were also present. No evidence was found suggesting the presence of the 10–20 per cent of a non-gelatin-like component reported by Russell.

The differences between resin batches were shown to be, in the main, accountable in terms of surface area. Two further gelatines (laboratory samples No. 142, *p*I 7·8 and No. 149, *p*I 9·4) of acid-process type showed similar behaviour to gelatin 127 (*p*I 4·95) but the corresponding percentages eluted were found at higher *p*H.

The third paper, "Some Factors influencing the Melting of Gelatin Gels", read by Dr. G. Stainsby, was based on his work with Mr. J. T. Taylor. After reviewing the arbitrary character of melting-point measurement, Dr. Stainsby described the Association's method, which uses as indicator the flow of a drop of carbon tetrachloride down the thin molten layer in contact with the wall of the thin-walled test-tube in which the gel has been set and matured.

The tube is held in a water-bath, the temperature of which is raised ½ deg. C./min. The method has the advantage of simplicity, thus enabling many variables to be studied. The main contribution of the paper was to show in which conditions the period of maturing of a gel has the most marked effect on its structure as shown by the melting point. If the gelatine solution is rapidly cooled, and then matured at a temperature of 0–10° C., the maturing, after the first hour, has no effect on the melting point, except for the most dilute gels where the setting takes an appreciable time. In contrast, at the higher maturing temperatures (20–25° C.) a marked increase in melting point may be secured by prolonged maturing. These differences in behaviour are presumed to arise from greater powers of re-orientation into stable aggregates at the higher temperature.

Interesting results were obtained by successive maturing at two temperatures. Whereas the melting point characteristic of high-temperature maturing was not changed when this maturing was followed by a further maturing period at a low temperature, the same was not true when the temperatures were reversed. High-temperature maturing could cause a rise in melting point even when it succeeded low-temperature maturing.

The formation of aggregates on cooling gelatin solutions to temperatures above their setting point can be detected by viscosity measurement. In addition, aggregates formed at 25° C. can persist for appreciable times even at 40° C. This work has a bearing on many uses of gelatine and glue, as well as on gel structure.

A. G. WARD

[1] Doty, P., and Nishihara, T., "Recent Advances in Gelatine and Glue Research", edit. by G. Stainsby, 92 (Pergamon Press, 1958).

[2] Russell, G., *Nature*, 181, 102 (1958).

[3] Maron, N., "Recent Advances in Gelatin and Glue Research", edit. by G. Stainsby, 221 (Pergamon Press, 1958).

NATIONAL RESEARCH COUNCIL OF CANADA

REPORT FOR 1957–58

THE forty-first annual report of the National Research Council of Canada, covering the year 1957–58*, includes the report of the president, Dr. E. W. R. Steacie, the financial statement, and the annual report of Canadian Patents and Development Ltd. Although the latter company shows a slight loss for the year, the prospects of increasing revenue from licences for oil additives, the crash position indicator, the multiple core yarn and the sedimentation device are stressed. During the year the Council provided 3·6 million dollars in support of pure research in the universities by way of 305 scholarships and fellowships, and its 583 scientific research staff (including 142 post-doctorate fellows), 854 technical and 888 general service and administration staff answered 9,500 technical inquiries from Canadian industries. For 1958–59 the Council has recommended that the support given to the universities should be increased to 6 million dollars, but continued growth of government research laboratories is also essential in view of certain limitations on research in industry in Canada.

In 1956, Dr. Steacie points out, Canadian secondary industries, which contribute 22 per cent of the net output and employ 20 per cent of civilian labour, spent about 80 million dollars on research, an increase of 20 per cent on 1955, but 65 per cent of this expenditure was made by a relatively few large companies. Compared with the United States or Great Britain expenditure on research by industry is relatively low.

A major effort is needed to bring about the type of expansion required, and the maintenance of a supply of competent scientists is a reason for ensuring that every encouragement is also given to research in the universities and in Government laboratories.

The Division of Applied Biology has undertaken fundamental work on the effects of irradiation on the development of rancidity in bacon and continued its investigation of railway refrigerator cars. Studies of the structure and development of plant cells and their constituents with the electron microscope were extended, and an improved assay procedure was developed for the toxin-neutralizing substance discovered in culture filtrates of *Penicillium cyanofulvum*, while conversions of up to 50 per cent of sugar to citric acid have been obtained by submerged fermentation of blackstrap molasses. The Atlantic Regional Laboratory completed a systematic survey of the composition of peat in seven large bogs in the Maritime Provinces and its further studies on laminarin sulphate as a blood-anticoagulant have shown that with large doses over a prolonged period this substance tends to be more toxic than heparin. The Prairie Regional Laboratory has developed special columns for the rapid analysis of components of vegetable oils by gas – liquid phase chromatography, and promising yields of lysine and ergot have been obtained by careful study of fermentation conditions, while a new method was developed for the direct separation of starch and gluten from wheat flour.

In the Division of Applied Chemistry, a silver catalyst was used in studying the oxidation of ethylene and propylene, and high-pressure work has included the conversion of gaseous and liquid aldehydes to solids, the measurement of rates of selected reactions as a function of pressure and the determination of changes in the physical properties of gases when highly compressed. The molecular weights of chemical compounds and polymers in the range 40,000–100,000 have been determined and the oxidation-rates of iron and its alloys measured over a range of temperatures by following the gain in weight and by cathodic reduction of the oxidation products. An extensive study was made of the kinetics of polymerization of styrene and α-methylstyrene initiated by sodium naphthalene and much work was done on the fabrication of silver alloys for oxidation catalysts.

In the Division of Pure Chemistry, work continued on the development of suitable methods for deuterating organic compounds, and a study was made of the instrumental conditions to be met to obtain infra-red spectra that are true physical constants of the absorbing compounds. Comprehensive measurements are being made of the specific heat of elements of the diamond structure (diamond, silicon and germanium) in the temperature region 2°–300° K. and a Calvet type microcalorimeter is being constructed. The study of the influence of surface forces on the rates of flow of fluids through capillary systems and of the nature of the forces responsible for the sorption of acids and dyes by textile fibres continued.

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* Forty-first Annual Report of the National Research Council of Canada, 1957–58, including the Annual Report of Canadian Patents and Development Limited. Pp. 54. (N.R.C. No. 4783.) (Ottawa: Queen's Printer, 1958.)

In its work on the control of noise, the Division of Applied Physics gave some attention to communication in high ambient noise. The process of establishing Canada's standards in electricity and mechanics is approaching completion. Temperature measurements of very high precision are being made to determine some of the limits of accuracy of the International Temperature Scale and to investigate the possibility of replacing later some of its fixed points. Besides work on the redefinition of the international metre, comprehensive studies on aerial triangulation continued, and detailed studies by the photometry laboratory should lead to an improved primary standard of light.

The Division of Pure Physics reports important advances in studies of the interaction of energetic μ-mesons with carbon nuclei; an extensive experimental study of the transition metals was completed; a new theory of the processes of strain hardening has been developed and a new type of phase transition in solids discovered. The structures of propiolic aldehyde and vinyl cyanide were determined in the microwave laboratory. A new approach to the general theory of relativity has been formulated on the basis of a new principle of observation.

In the Division of Mechanical Engineering, a very thorough investigation was made into the status of production, research and development in non-metallic structural materials in Canada, and work was almost completed on several projects for the St. Lawrence Seaway. Besides problems related to the design and powering of ships, substantial work was undertaken on the examination of aircraft turbo-jet and turbo-propeller engines under simulated icing conditions. Work is in progress on the aerodynamic problems of aircraft capable of vertical take-off and short take-off, and on techniques for measuring the dynamic characteristics of aircraft at high speeds. An emergency radio beacon, simple and light in weight, was developed by the Radio and Engineering Division to survive aeroplane crashes, as well as a device using transistors to switch off electric buoy lights during daylight and a photoelectric control which puts the diesel-electric plant at Pelee Passage lighthouse into operation between dusk and dawn. Microwave equipment is being developed to provide accurate fixes of position for hydrographic vessels, and a method was devised for measuring the gradient of voltage across each unit of a high-voltage suspension insulator string. Daily observations of 10-cm. radio-emission from the Sun were continued at the Radio Astronomy Observatory, and completion of the Springhill Meteor Observatory provided a new headquarters for meteor research, while auroral radar units are being operated continuously at four stations.

ACTION OF LIGHT ON VISUAL PIGMENTS

from

THE BIOLOGICAL LABORATORIES, HARVARD UNIVERSITY

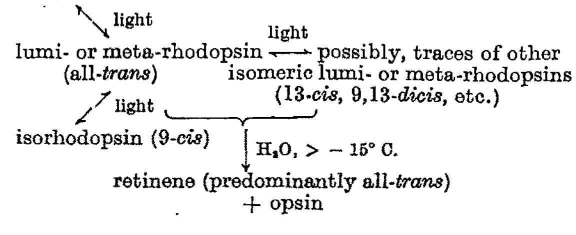
Vertebrate Lumi- and Meta-rhodopsins

By DR. RUTH HUBBARD, PAUL K. BROWN and DR. ALLEN KROPF*

RHODOPSIN, the red photosensitive pigment of rod vision, consists of the colourless protein, rod opsin or scotopsin, carrying neo-*b* (11-*cis*) retinene as chromophore. In the light, rhodopsin bleaches through orange-red intermediates (lumi- and meta-rhodopsin) to the yellow mixture of all-*trans* retinene and opsin.

The bleaching of rhodopsin proceeds in three steps, the first photochemical, followed by two thermal reactions[1]. Light initiates this reaction sequence by isomerizing the *cis* chromophore of rhodopsin to the all-*trans* configuration, so converting rhodopsin to the all-*trans* chromoprotein, lumirhodopsin[2,3]. Below about −40° C. lumirhodopsin is stable[1]; above this temperature it changes in light or darkness to a second all-*trans* chromoprotein, metarhodopsin[1-3]. Below about − 15° to − 20° C. metarhodopsin is stable[1]. At higher temperatures, all known vertebrate metarhodopsins hydrolyse spontaneously in the dark to all-*trans* retinene and opsin. Only this last reaction entails a major change in colour, that is, bleaching. Visual excitation, however, is so rapid as to leave time only for the first or second step, and must therefore precede bleaching[1,2].

Light, having isomerized the *cis* chromophore of rhodopsin to the all-*trans* configuration (lumi- or meta-rhodopsin), can go on to isomerize this to *cis* configurations, thus forming rhodopsin (11-*cis*), and isorhodopsin (9-*cis*). In conditions under which lumi- or meta-rhodopsin are stable, prolonged irradiation therefore always yields stereoisomeric mixtures of lumi- or meta-rhodopsin with photoregenerated rhodopsin and isorhodopsin. This situation can be summarized as follows[2,3]:


rhodopsin (11-*cis*)
light
lumi- or meta-rhodopsin
(all-*trans*)
light
possibly, traces of other isomeric lumi- or meta-rhodopsins (13-*cis*, 9,13-*dicis*, etc.)
light
isorhodopsin (9-*cis*)
H₂O, > − 15° C.
retinene (predominantly all-*trans*) + opsin

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* Present address: Chemistry Department, Amherst College, Amherst, Mass.

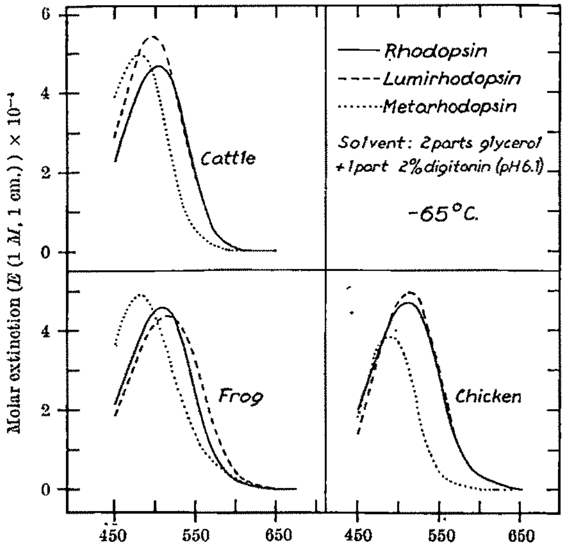


Fig. 1. Absorption spectra of rhodopsins, lumirhodopsins and metarhodopsins from cattle, bullfrog (*R. catesbiana*) and chicken. Rhodopsin spectra were measured directly; lumi- and metarhodopsin spectra obtained as described in the text. All are averages of 2–4 experiments. The extinction coefficients of the rhodopsins at – 65° C. were derived from the extinction coefficients at room temperature, by cooling solutions of known extinction to – 65° C., and correcting for volume shrinkage of the solvent (4·5 per cent). The extinction coefficients of cattle and frog rhodopsin in glycerol–digitonin at room temperature ($\epsilon_{max.}$ = 42,000) were measured by methods previously described (ref. 7), and assumed to be the same for chicken rhodopsin. The extinction coefficients of the lumi- and meta-rhodopsins were obtained by measuring the extinction of rhodopsin which disappeared when a given extinction of lumi- or meta-rhodopsin was formed (cf. Fig. 3). Cattle rhodopsin was prepared from isolated rod outer limbs (ref. 10); bullfrog rhodopsin from alum-hardened retinas (ref. 14). Chicken rhodopsin was obtained by incubating a preparation of mixed rod and cone opsins (ref. 15) with excess neo-*b* retinene. This yields a mixture of chicken rhodopsin and iodopsin. The iodopsin, which is labile in the presence of hydroxylamine (ref. 15), is then destroyed by incubating the mixture ½ hr. at room temperature with 0·3 *M* hydroxylamine

We have recently examined lumi- and metarhodopsins from five species of vertebrates, and two cephalopods. These are described in the present and following communications. However, we must first clarify our terminology.

We use the terms *lumirhodopsin* and *metarhodopsin* to designate the two all-*trans* chromoproteins resulting from the photoisomerization of rhodopsin. As will be seen, the spectroscopic properties of these compounds—wave-length of maximum absorption ($\lambda_{max.}$) and molar extinction coefficient at $\lambda_{max.}$ ($\epsilon_{max.}$)—differ somewhat from one species to another. Rhodopsins also exhibit species variations in these properties[4,5]; yet we designate as a *rhodopsin* any visual pigment composed of neo-*b* retinene and a rod opsin. The fact is that rod opsins, like most proteins, differ somewhat from one species to another, and this leads to species differences in the absorption properties of the rhodopsins, and lumi- and metarhodopsins.

Experimental results. The absorption properties at – 65° C. of the rhodopsins, lumirhodopsins, and metarhodopsins from five species of vertebrates are shown in Figs. 1 and 2, and summarized in Table 1. The information in each case is obtained from the type of experiment illustrated in Fig. 3.

Table 1. ABSORPTION PROPERTIES OF THE VISUAL CHROMOPROTEINS FROM FIVE SPECIES OF VERTEBRATES, MEASURED IN 2 : 1 GLYCEROL–DIGITONIN AT – 65° C.

Half-widths of the absorption bands are obtained, by subtraction, from the two wave-lengths or frequencies at which the extinction is half maximal

Species	$\lambda_{max.}$ (mμ)	$\epsilon_{max.}$ (litre/ mole-cm.)	Half band-width wave-length (mμ)	Half band-width frequency (10^{14}/sec.$^{-1}$)
		Rhodopsins		
Monkey	500	49,000	100	1·26
Cattle	504	47,000	96	1·17
Chicken	512	47,000	96	1·13
Bullfrog	508	46,000	98	1·17
Cusk	500	52,000	100	1·26
		Lumirhodopsins		
Monkey	500	56,000	87	1·05
Cattle	497	54,000	92	1·13
Chicken	513	49,000	94	1·09
Bullfrog	515	43,500	106	1·23
Cusk	519	54,000	96	1·09
		Metarhodopsins		
Monkey	482	48,000	83	1·09
Cattle	481	50,000	86	1·14
Chicken	489	38,000	83	1·05
Bullfrog	482	49,000	91	1·18
Cusk	507	39,000	108	1·30

Rhodopsin in 2 per cent aqueous digitonin is mixed with two volumes of glycerol, and to 0·3 ml. of this solution 0·005 ml. 1 *M* hydroxylamine is added. The solution and a blank of 2 : 1 glycerol–digitonin are cooled to – 65° C. in the modified, insulated cell compartment of a Beckman *DU* spectrophotometer, by circulating through Beckman thermospacers acetone from a reservoir chilled with solid carbon dioxide. The temperature in the cell compartment is measured with an iron-constantan thermocouple attached to the Beckman cell holder (reference junction at 0° C.). The absorption spectrum of the rhodopsin preparation is measured (Fig. 3, spectrum 1), and the rhodopsin is then irradiated in place in the cell compartment until all spectroscopic changes are essentially completed (Fig. 3, spectrum 2). The irradiation is performed with light from a 100-watt

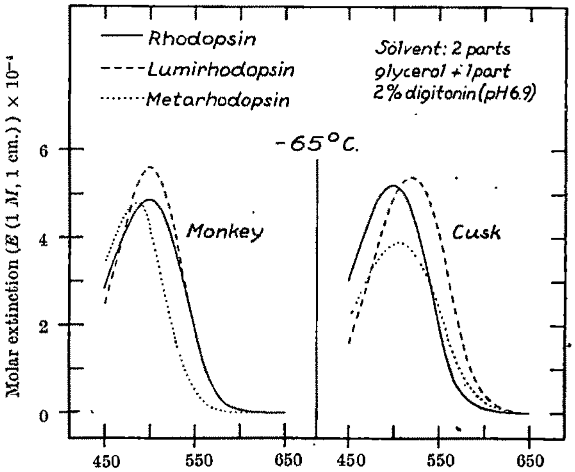


Fig. 2. Absorption spectra of rhodopsins, lumirhodopsins and metarhodopsins from monkey (*Rhesus*) and cusk (*Brosme brosme* Müller). Spectra obtained as in Fig. 1. Monkey rhodopsin was prepared by incubating rod outer limbs, isolated from light-adapted, frozen and thawed retinas, with excess neo-*b* retinene (refs. 8 and 10). The rods were then washed with buffer and water, hardened in alum, lyophilized, and extracted with petroleum ether. Rhodopsin was finally extracted with 2 per cent digitonin. Cusk rhodopsin was synthesized in solution by incubating cusk opsin, extracted from isolated rod outer limbs, with a limiting amount of neo-*b* retinene (refs. 4 and 16)

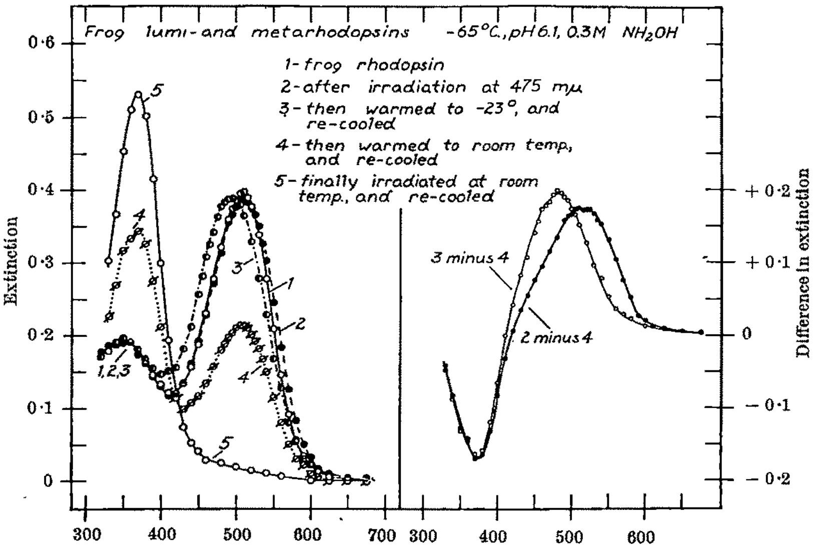


Fig. 3. Formation of bullfrog lumi- and meta-rhodopsin. Experimental details are described in the text. The sample was irradiated 1 hr. at 475 mμ (half band-width about 6 mμ)

zirconium arc, dispersed by a Bausch and Lomb grating monochromator (1,200 lines per mm., 250 mm. focal length), which enters the cell compartment through a window, on opening a photographic shutter.

Prolonged irradiation at − 65° C. produces mixtures composed of lumirhodopsin, photoregenerated rhodopsin, and isorhodopsin (Fig. 3, spectrum 2). Upon warming the mixture in the dark to between about − 30° and − 20° C., the lumirhodopsin is converted to metarhodopsin, whereas the other two components remain unchanged. This change in temperature is achieved by shutting off the flow of cold acetone until the desired temperature is reached, and maintaining it either with sporadic bursts of cold acetone, or by circulating ethylene glycol from a constant-temperature bath (American Instrument Co.) at about − 30° C.

The sample is then re-cooled to − 65° C., and the spectrum again measured (Fig. 3, spectrum 3). (The absorption spectra of these pigments are somewhat dependent on temperature[1,6]. Successive spectra must therefore be compared at the same temperature.) The sample in its absorption cell is now removed from the cold cell compartment, and kept at room temperature in the dark for about ½ hr. As mentioned above, under these conditions vertebrate metarhodopsins hydrolyse to opsin and all-*trans* retinene, which in the present experiments immediately reacts with hydroxylamine to form retinene oxime[7]. After re-cooling the solution to −65° C. (Fig. 3, spectrum 4), one observes the absorption bands of retinene oxime ($\lambda_{max.}$ 369 mμ), and rhodopsin and isorhodopsin, the latter having previously been masked by lumi- and meta-rhodopsin. Rhodopsin and isorhodopsin are finally converted to all-*trans* retinene oxime by irradiation at room temperature (Fig. 3, spectrum 5).

Fig. 3 (right) shows the difference spectra of bull-frog lumi- and meta-rhodopsin, obtained by subtracting spectrum 4 from spectra 2 and 3. Since these difference spectra are measured in the presence of hydroxylamine, they are equivalent to absorption spectra at wave-lengths longer than about 450 mμ, at which retinene oxime has negligible absorption[8]. All the results in Figs. 1 and 2 were obtained from this type of experiment.

That the product of irradiating rhodopsin in the cold is not a single substance, but such a mixture of chromoproteins as we have described, is further demonstrated in Fig. 4. Here cattle rhodopsin at −65° C. is irradiated at 450 mμ or 500 mμ. It is clear that the absorption spectra of the resultant products (spectra 2) depend upon the wave-length at which they are produced[2]. After warming the products, to convert lumirhodopsin to all-*trans* retinene oxime (spectra 3), one sees that the difference in spectrum is caused by a difference in composition: irradiation at longer wave-lengths favours the production of isorhodopsin (the component which absorbs at shortest wave-lengths ($\lambda_{max.}$ 490 mμ at − 65° C.)), whereas irradiation at shorter wave-lengths favours rhodopsin (see also Fig. 6 of ref. 2). Lumirhodopsin, in both cases, possesses a difference spectrum of the same shape and $\lambda_{max.}$ (Fig. 4, right).

Discussion. The shapes and wave-length maxima of the absorption spectra of the chromoproteins from the five vertebrates we have examined are summarized in Fig. 5. As can be seen from Fig. 5 and

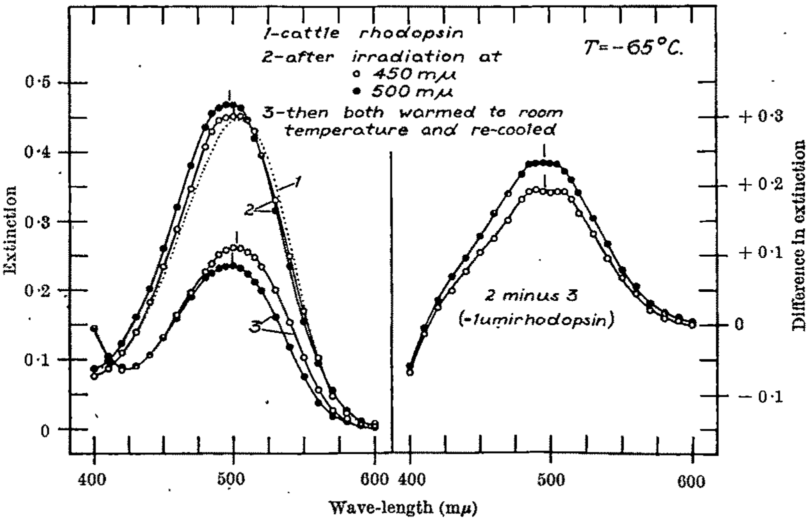


Fig. 4. Mixtures of chromoproteins obtained by irradiating cattle rhodopsin at 450 and 500 mμ. Experimental details are described in the text. Irradiation at 450 mμ was continued 1½ hr.; at 500 mμ, 1 hr.; both at half band-widths of about 6 mμ. Neither irradiation was sufficiently long to yield the steady state mixture of chromoproteins (cf. refs. 2 and 3)

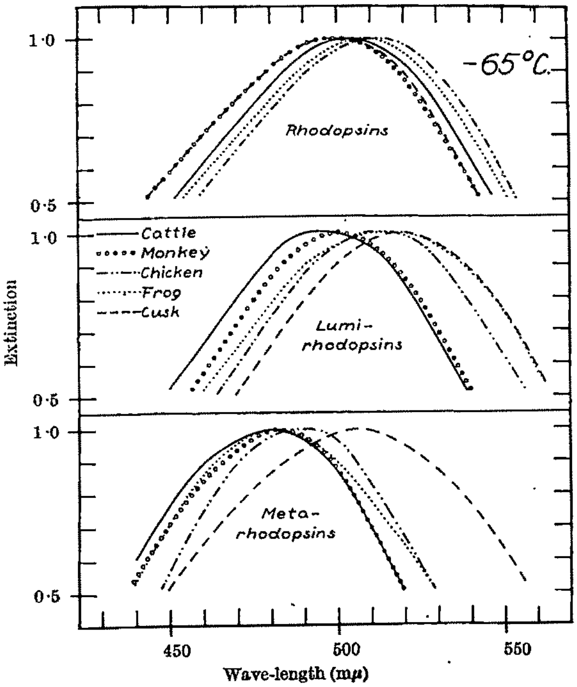


Fig. 5. Absorption spectra of the visual chromoproteins from five species of vertebrates. For comparison, all spectra are brought to an extinction of 1·0 at $\lambda_{max.}$

Table 1, the half-widths of the absorption bands (particularly on a frequency basis) exhibit little, if any, species variation, and furthermore are similar for all three classes of pigments. (The most outstanding exception is cusk metarhodopsin, and for the following reason. Metarhodopsins from different species differ somewhat in their thermostabilities. Thus, frog and especially cusk metarhodopsins hydrolyse more readily than the others. In the experiments with cusk chromoproteins, it is therefore difficult to find a temperature at which lumirhodopsin is converted completely to metarhodopsin, before some of the metarhodopsin has already hydrolysed to retinene and opsin. It is therefore likely that the spectrum of cusk 'metarhodopsin' in fact represents a mixture of lumi- *and* meta-rhodopsin. This would account for its width, and for the fact that its $\lambda_{max.}$ lies at a considerably longer wave-length than those of the other metarhodopsins.)

That $\lambda_{max.}$ varies with species is obvious for all three pigments. We have suggested elsewhere that the colour of the visual chromoproteins depends on an intimate steric fit between the chromophore and the opsin, which permits them to interact in such a way as to increase the resonance stabilization of the first excited state of the chromophore[3,9]. Species differences in the opsins modify the colours of these compounds, presumably by affecting these steric relationships with the chromophore.

The sets of chromoproteins from any one species exhibit some regularities. Thus, $\lambda_{max.}$ of lumirhodopsin in general lies at the same or longer wave-length as that of the corresponding rhodopsin; and always at a longer wave-length than that of the corresponding metarhodopsin.

We have postulated that the transformation of rhodopsin to lumirhodopsin involves, primarily, a configurational change of the chromophore; the transformation of lumirhodopsin to metarhodopsin, a change in configuration of the opsin[2]. In brief, this conclusion is based on the following arguments.

At the temperatures at which lumirhodopsin is stable (that is, below about − 45° C.), the glycerol–digitonin system forms a highly viscous liquid, or glass, which melts over the temperature-range in which lumirhodopsin changes to metarhodopsin. In the glass at low temperatures, the opsin probably has little or no freedom to change configuration, so that one can isolate the primary photochemical event—the photoisomerization of the chromophore. As the temperature is raised, however, the opsin becomes re-arranged to a new, more stable configuration.

Numerous lines of evidence indicate that the configuration of the protein is different in rhodopsin and opsin[10-12]. Furthermore, it has been shown with the squid chromoproteins that opsin reacts differently in rhodopsin and metarhodopsin[13]. This suggests that the polypeptide chain of opsin assumes one configuration in the presence of the 11-*cis* chromophore (rhodopsin), another in combination with the all-*trans* chromophore (metarhodopsin), and a third in the absence of a chromophore (opsin). When, as a result of irradiation at − 65° C., the *cis* chromophore of rhodopsin is isomerized to all-*trans* (lumirhodopsin), the configuration of the protein is unstable, but cannot become rearranged to that of metarhodopsin until the system is rendered more fluid by raising the temperature.

A further observation is in line with the above interpretation. Rhodopsin and lumirhodopsin are freely interconvertible by irradiation at − 65° C., as shown above. Likewise, rhodopsin and metarhodopsin are readily interconverted by irradiation at − 20° C.[2,3]. However, we find that *irradiation of metarhodopsin at − 65° C. does not yield rhodopsin,* just as irradiation of rhodopsin at this temperature fails to yield metarhodopsin. We conclude that the low temperature blocks re-arrangement of opsin *in both directions*. A thermal loosening of structure is required to render the two states interconvertible.

The reaction sequence involved in the bleaching of vertebrate rhodopsin can be summarized as follows:

Reaction	Product	Colour
	Rhodopsin (11-*cis*)	red
1. Photochemical stereoisomerization of the chromophore	⇅	
	Lumirhodopsin (all-*trans*)	red to purple
2. Thermal rearrangement of the opsin	↓	
	Metarhodopsin (all-*trans*)	orange to red
3. Hydrolysis of the chromophore from opsin	↓	
	Retinene (all-*trans*) + Opsin	yellow

Species differences in opsin introduce minor differences in the absorption properties and thermal stabilities of the individual chromoproteins; but the general scheme is the same for all the vertebrate rhodopsins we have examined.

As mentioned above, visual excitation almost surely precedes the release of retinene, and apparently is triggered by the transformation of rhodopsin to lumi- or meta-rhodopsin. The rearrangement of the protein in going from lumi- to meta-rhodopsin could conceivably be the triggering reaction, perhaps by unmasking new reactive groups, or changing the charge distribution of the molecule, and so producing a transient, localized pocket of positivity or negativity in the rod outer limb.

The experiments described in the present and two succeeding communications were performed with the financial support of grants to Prof. George Wald from the Rockefeller Foundation, the Office of Naval Research, and the Division of Neurological Diseases and Blindness of the U.S. Public Health Service (Grant *B*-568 *C*4); and while one of us (A. K.) was Fellow in Cancer Research of the American Cancer Society. We should like to thank Prof. George Wald for many helpful discussions and suggestions. We are grateful to Eli Lilly and Co., of Indianapolis, for supplying us with monkey eyes; and to the Phillips Poultry Supply, of East Boston, for gifts of fresh chicken heads.

Lumi- and Meta-rhodopsins of Squid and Octopus

By DR. ALLEN KROPF, PAUL K. BROWN and DR. RUTH HUBBARD

WE have extracted rhodopsins from four species of invertebrates: three cephalopods, namely, squid (*Loligo pealii*)[13,17], cuttlefish (*Sepia officinalis*)[18], and octopus (*Octopus vulgaris*)[18], and one decapod crustacean—the lobster (*Homarus americanus*)[19]. These rhodopsins, like those of vertebrates, are composed of neo-*b* (11-*cis*) retinene attached as chromophore to colourless proteins, members of the family of opsins[2,13,18]. Light isomerizes the *cis* chromophore to the all-*trans* configuration, so transforming invertebrate, like vertebrate, rhodopsins to the all-*trans* chromoproteins, lumi- and meta-rhodopsin[3,13] (see also first communication). However, whereas vertebrate metarhodopsins readily hydrolyse to all-*trans* retinene and opsin[1,2] (see also first communication) the four invertebrate metarhodopsins which have been examined are relatively stable[13,17–19].

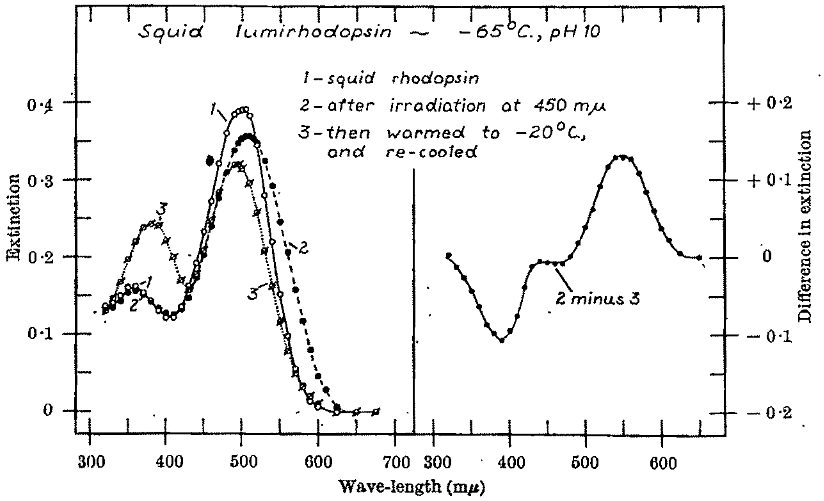


Fig. 6. Formation of squid lumirhodopsin, and its conversion to alkaline metarhodopsin. Squid rhodopsin in 2 per cent aqueous digitonin, prepared as previously described (ref. 13), was mixed with two volumes of glycerol and brought to *p*H 10 by addition of solid sodium carbonate. The solution was cooled to − 65° C. in the Beckman spectrophotometer (see first communication), and its spectrum measured against a blank of 2 : 1 glycerol–digitonin (spectrum 1). The preparation was then irradiated 2 hr. at 450 mμ (half band-width about 6 mμ), and its spectrum re-measured (spectrum 2). To convert lumirhodopsin to metarhodopsin, the solution was warmed to − 20° in the dark for about an hour, and its spectrum measured after cooling to − 65° C. (spectrum 3). Upon subtracting spectrum 3 from 2, one obtains the difference spectrum of lumirhodopsin, shown at the right

As previously shown, the further irradiation of metarhodopsin re-isomerizes its all-*trans* chromophore to the neo-*b* configuration, thus regenerating rhodopsin[3,13]. The cephalopod rhodopsin systems in their simplest form can therefore be summarized[13,18]:

$$\text{rhodopsin} \xrightleftharpoons{\text{light}} \text{metarhodopsin}$$

One other property is shared by the cephalopod metarhodopsins, though not by that of the lobster. All three are *p*H indicators, red ($\lambda_{\max.}$ about 500 mμ) in neutral or mildly acid solution, and yellow ($\lambda_{\max.}$ 380 mμ) in alkaline solution[13,18]. The interconversion of the two forms involves the reversible dissociation of a hydrogen ion, probably from the Schiff base linkage ($—CH{=}N— + H^+ \rightleftharpoons —CH{=}\overset{+}{N}H—$), which attaches the retinene chromophore to opsin[3,9,13,20]:

$$\underset{(\lambda_{\max.}\ \text{about}\ 500\ \text{m}\mu)}{\text{acid metarhodopsin}} \rightleftharpoons \underset{(\lambda_{\max.}\ 380\ \text{m}\mu)}{\text{alkaline metarhodopsin}} + H^+$$

The chromophore of rhodopsin appears to be a protonated Schiff base, like that of acid metarhodopsin[3,9]. The rhodopsin system of cephalopods therefore includes the reversible loss of a hydrogen ion[13,18]:

$$\begin{tikzcd}\text{rhodopsin} \arrow[r, shift left, "\text{light}"] & \text{acid metarhodopsin} \arrow[l, shift left, "\text{light}"] \arrow[r, shift left, "-H^+"] & \text{alkaline metarhodopsin} \arrow[l, shift left, "+H^+"] \arrow[ll, bend left, "\text{light} + H^+"]\end{tikzcd}$$

Preliminary experiments at low temperatures (− 45° C.) suggested that squid rhodopsin, like those of vertebrates, is converted by light to lumirhodopsin, and that a second, thermal reaction turns the latter into metarhodopsin[21]. We have investigated the lumi- and meta-rhodopsins from two cephalopods, squid and octopus, by the methods described in the preceding communication.

Experimental results. Squid rhodopsin in alkaline solution (2 : 1 glycerol–digitonin, *p*H 10) is chilled to −65° C. (Fig. 6, spectrum 1). Upon irradiation, the absorption spectrum changes as shown in Fig. 6: the extinction falls at wave-lengths shorter than 510 mμ, and rises at longer wave-lengths, owing to the formation of a mixture of chromoproteins, namely, lumirhodopsin, regenerated rhodopsin, and isorhodopsin (first communication). If this mixture is warmed in the dark to −20° C., rhodopsin and isorhodopsin remain unchanged, but lumirhodopsin at this *p*H is converted to alkaline metarhodopsin ($\lambda_{\max.}$ 380 mμ), as shown in spectrum 3 (Fig. 6). The difference spectrum of lumirhodopsin, obtained by subtracting spectrum 3 from 2, is shown at the right of the figure. Since alkaline metarhodopsin has essentially no absorption at wave-lengths longer than about 500 mμ (cf. Fig. 8), above that wave-length this difference spectrum is equivalent to the absorption spectrum of lumirhodopsin.

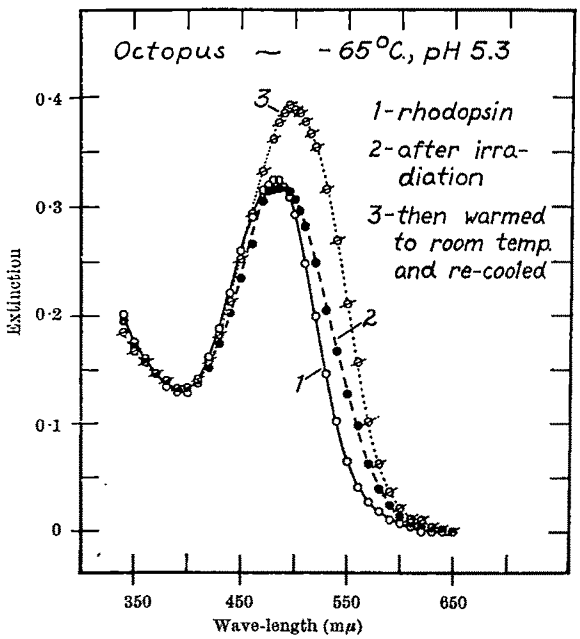


Fig. 7. Formation of octopus lumirhodopsin, and its conversion to acid metarhodopsin. Octopus rhodopsin in 2 per cent aqueous digitonin was prepared from eyes of frozen and thawed Portuguese octopus as previously described (ref. 18), and mixed with two volumes of glycerol. It was then brought to pH 5·3 by addition of 0·005 ml. 1 M acetate buffer (pH 4·7) to 0·3 ml. of solution, cooled to − 65° C., and its spectrum measured against 2 : 1 glycerol–digitonin as blank (spectrum 1). It was then irradiated 1 hr. at 470 mμ (6 mμ half band-width) and the spectrum re-measured (spectrum 2). The solution was now warmed to room temperature to convert lumirhodopsin to acid metarhodopsin, and the spectrum measured after re-cooling (spectrum 3). The increase in extinction at wave-lengths longer than about 450 mμ is due to the conversion of lumirhodopsin to acid metarhodopsin

The same experiment, performed with octopus rhodopsin, yields similar results, differing only in spectroscopic detail, since the absorption spectra of the chromoproteins from squid and octopus differ somewhat (cf. Table 2, and Figs. 8 and 9).

As with the vertebrate systems, the relative amounts of each isomeric chromoprotein in the mixture vary following irradiation at different wave-lengths. But the spectrum of each component—lumirhodopsin, rhodopsin, and isorhodopsin—is independent of the conditions under which it is produced (first communication).

Irradiation of squid or octopus rhodopsin at − 65° C. in neutral or mildly acid solution yields mixtures of chromoproteins identical with those obtained in alkaline solution. However, warming under these conditions converts lumirhodopsin to acid rather than alkaline metarhodopsin. In other words, the absorption spectra of the cephalopod lumirhodopsins are invariant with pH. Indicator properties appear only at the level of metarhodopsin. An experiment with octopus rhodopsin at pH 5·3 is shown in Fig. 7.

Table 2. ABSORPTION PROPERTIES OF RHODOPSIN, LUMIRHODOPSIN, AND THE METARHODOPSINS FROM SQUID (*Loligo pealii*) AND OCTOPUS (*Octopus vulgaris*) IN 2 : 1 GLYCEROL–DIGITONIN AT − 65° C. Half-widths of absorption bands, determined as described in the first communication, are given in terms of wave-length (mμ) and frequency (sec.$^{-1}$)

Absorption characteristics	Rhodopsin	Lumi-rhodopsin	Metarhodopsin Acid	Metarhodopsin Alkaline
		Squid		
$\lambda_{\text{max.}}$ (mμ)	500	550	500	385
$\varepsilon_{\text{max.}}$ (litre/mole-cm.)	48,000	64,000	65,500	66,500
Half band-width :				
(mμ)	102	83	102	76
(10^{14} sec.$^{-1}$)	1·28	0·84	1·29	1·61
		Octopus		
$\lambda_{\text{max.}}$ (mμ)	483	508	505	
$\varepsilon_{\text{max.}}$ (litre/mole-cm.)	43,000	38,000	63,000	
Half band-width :				
(mμ)	98	94	105	
(10^{14} sec.$^{-1}$)	1·31	1·13	1·29	

(It should be noted that pH is always measured above 0° C., leaving one to surmise from this the hydrogen ion concentrations at − 20° and − 65° C. The fact that squid and octopus metarhodopsins exhibit the usual pH indicator properties at − 20° C. serves as something of an internal check on the pH of the system at that temperature. Another indication that the difference in hydrogen ion concentration between the acid and alkaline samples is maintained at least to some extent at the low temperatures is offered by the fact that acid or alkaline metarhodopsin, prepared above 0° C., maintains its identity upon lowering the temperature to − 20°, and − 65° C. (compare Fig. 3 of ref. 2 with Fig. 8 herewith).)

The absorption properties of the chromoproteins from squid and octopus, obtained from the types of experiment shown in Figs. 6 and 7, are summarized in Figs. 8 and 9, and in Table 2. The absorption spectrum of octopus alkaline metarhodopsin has not been included because it closely resembles that of the squid pigment.

Discussion. The absorption maximum of octopus rhodopsin lies at considerably shorter wave-lengths than that of squid rhodopsin, and this is even truer of the lumirhodopsins from the two species. Their metarhodopsins, however, are almost identical. The spectroscopic picture of the conversion of lumirhodopsin to acid metarhodopsin is therefore quite different with the two animals. In the squid, lumirhodopsin

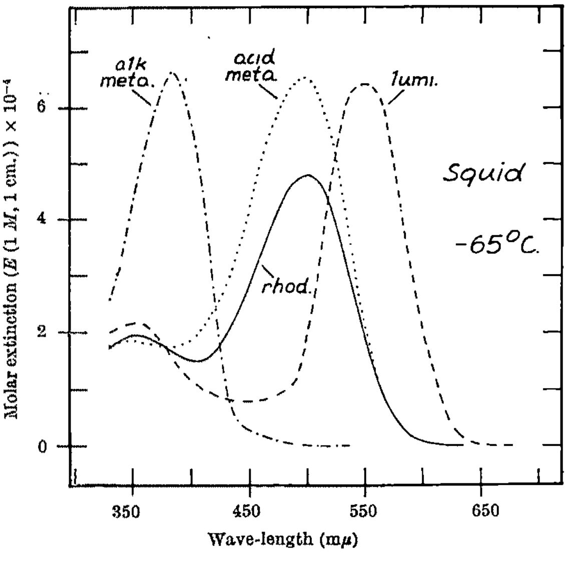


Fig. 8. Absorption spectra of squid chromoproteins in 2 : 1 glycerol–digitonin at − 65° C. The molar extinctions of rhodopsin and the two forms of metarhodopsin are derived from the extinction coefficients at + 5° C. (ref. 13), by cooling solutions of known extinction at that temperature to − 65° C., and correcting for volume shrinkage (3·7 per cent). The molar extinction of lumirhodopsin is obtained by measuring the extinction of rhodopsin which disappears when a given extinction of lumirhodopsin is formed (cf. Fig. 6). The spectrum of lumirhodopsin below 500 mμ is extrapolated by inserting the extinctions of alkaline metarhodopsin into the difference spectrum shown in Fig. 6. The results are averages from two experiments

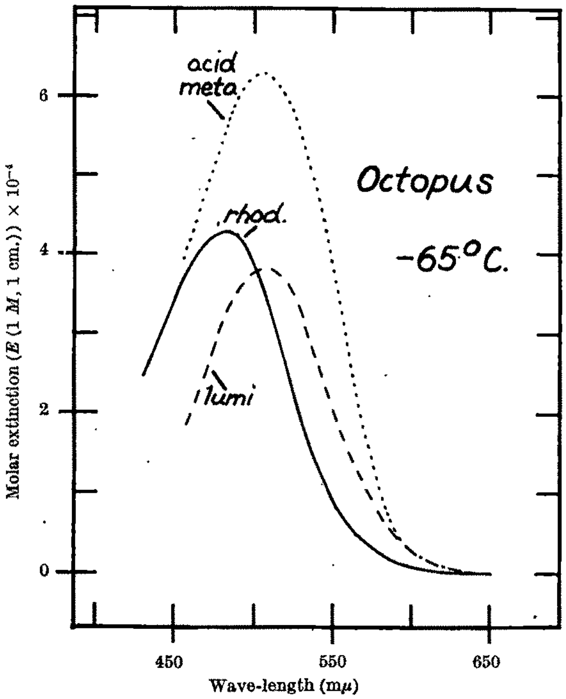
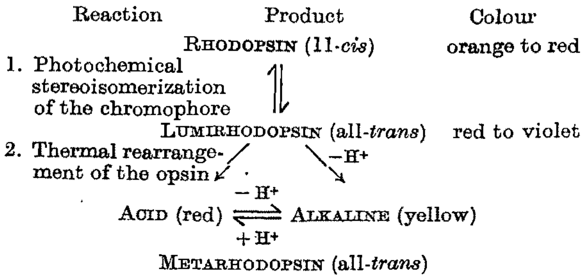


Fig. 9. Absorption spectra of octopus chromoproteins in 2 : 1 glycerol–digitonin at − 65° C. The molar extinction of rhodopsin at this temperature is obtained from that at + 2° C. (ref. 18) as described above. The absorption properties of lumirhodopsin are obtained from the type of experiment shown in Fig. 6, as described above. The absorption properties of acid metarhodopsin are derived from experiments like that shown in Fig. 7, by warming the solution containing acid metarhodopsin (Fig. 7, spectrum 3) to room temperature and raising the pH to about 9, to convert acid to alkaline metarhodopsin. The spectrum is then measured after re-cooling the solution to − 65° C., and the difference spectrum of acid metarhodopsin obtained in the same way as that of lumirhodopsin

and acid metarhodopsin have almost the same extinctions, and the transformation involves primarily the relatively large shift of $\lambda_{\text{max.}}$ from 550 to 500 mμ. In the octopus, the situation is reversed: $\lambda_{\text{max.}}$ remains virtually unchanged, while $\varepsilon_{\text{max.}}$ increases from 38,000 to 63,000. A possible interpretation of such species differences is discussed in the first communication.

We have mentioned previously that irradiation converts vertebrate metarhodopsin to rhodopsin at − 20° C., but not at − 65° C. (first communication). This is true also of the cephalopod pigments, and can be seen particularly clearly in interconversions between rhodopsin and alkaline metarhodopsin, because of the wide separation of their absorption maxima. Irradiation of alkaline metarhodopsin at + 5° C. yields rhodopsin and isorhodopsin[13]. We find that the same occurs at − 20° C., and *not* at − 65° C. Just as with the vertebrate pigments, the interconversion of rhodopsin and metarhodopsin is blocked in *both* directions at − 65° C. We assume this to be due to a lack of mobility of opsin at that temperature (first communication).

The observations on cephalopod pigments are consistent with our previous view that the reaction, rhodopsin→lumirhodopsin, involves a change in configuration of the chromophore, whereas the reaction, lumirhodopsin→metarhodopsin involves a configurational rearrangement of opsin (first communication). The reactions initiated by the irradiation of cephalopod rhodopsins can therefore be summarized :


Reaction
Product
Colour
RHODOPSIN (11-*cis*)
orange to red
1. Photochemical stereoisomerization of the chromophore
LUMIRHODOPSIN (all-*trans*)
red to violet
2. Thermal rearrangement of the opsin
−H⁺
− H⁺
ACID (red)
ALKALINE (yellow)
+ H⁺
METARHODOPSIN (all-*trans*)

Since the cephalopod visual systems do not include the hydrolysis of metarhodopsin to retinene and opsin, visual excitation of these animals must be triggered by the conversion of rhodopsin to metarhodopsin, perhaps by the second phase of this process—the conversion of lumirhodopsin to metarhodopsin—which involves configurational changes in opsin (first communication). The present experiments show that in cephalopods the transformation of lumi- to meta-rhodopsin introduces pH indicator properties, owing to the possibility of dissociating a hydrogen ion from the metarhodopsin chromophore. The re-arrangement of opsin could involve further changes in charge, and it is possible that such changes are the sources of visual excitation.

Chicken Lumi- and Meta-iodopsin

By Dr. RUTH HUBBARD and Dr. ALLEN KROPF

THE first cone pigment was extracted from chicken retinas by Wald[22]. Although he was unable to purify and concentrate the visual pigment sufficiently to see its colour, he named it iodopsin on the basis of its absorption properties (*ion* = violet, Gr.). In the course of the present investigation, we have finally had a glimpse of pure iodopsin in sufficient concentration to confirm Wald's inference.

Like rhodopsin, iodopsin consists of neo-*b* (11-*cis*) retinene joined as chromophore to a colourless protein, an opsin[15]. The opsins of rhodopsin and iodopsin, however, differ substantially, and have been named rod opsin (or scotopsin) and cone opsin (or photopsin)[15]. The rhodopsin and iodopsin systems involve the same isomerization cycle of retinene: both photopigments are synthesized from neo-*b* retinene, and bleach in the light to all-*trans* retinene and the corresponding opsin[15].

As already noted[2,3] (see also first communication), the photochemical bleaching of rhodopsin involves a sequence of photochemical and thermal reactions, which yield as intermediates the two all-*trans* chromoproteins, lumi- and meta-rhodopsin. Using the same methods, we now find a similar sequence of reactions in the bleaching of iodopsin.

Light converts iodopsin to a first unstable product, which we call lumi-iodopsin. Above about − 45° C., this is converted in the dark to a second unstable product, meta-iodopsin. The latter hydrolyses in the dark above about − 30° C. to all-*trans* retinene and cone opsin. Furthermore, just as irradiation of lumi- or meta-rhodopsin converts it to rhodopsin by isomerizing its all-*trans* chromophore to the 11-*cis* configuration, irradiation of lumi- or meta-iodopsin re-isomerizes its all-*trans* chromophore to 11-*cis*, yielding iodopsin. A complete parallelism is seen therefore between the rhodopsin and iodopsin systems.

Experimental results. Before describing the interconversions of iodopsin with lumi- and meta-iodopsin

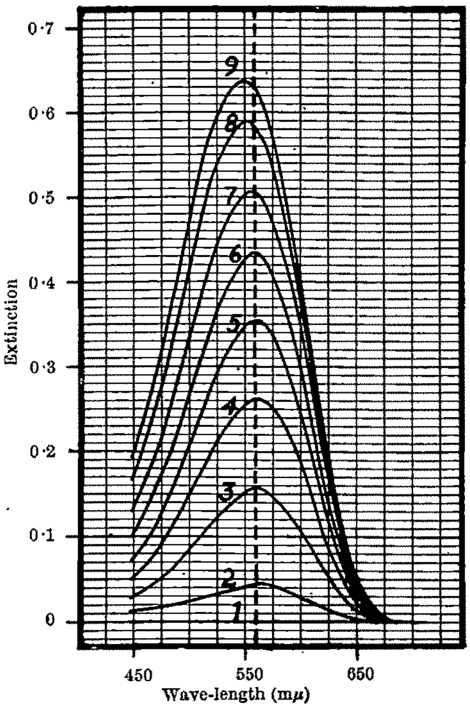


Fig. 10. Synthesis of iodopsin in aqueous 2 per cent digitonin (*p*H 6·1). The opsins (rod and cone) were extracted from light-adapted chicken retinas (ref. 15), and 0·2 ml. of the extract was balanced in the Cary recording spectrophotometer against another sample of the same solution as blank (spectrum 1). Successive portions of neo-*b* retinene (approximately 0·7 mμmol. in 0·005 ml. 1 per cent digitonin) were added, and spectra recorded 5 min. after each addition (spectra 2 to 9). Chicken cone opsin has a much greater affinity for neo-*b* retinene than rod opsin. The first five additions, therefore, resulted in the formation of iodopsin alone ($\lambda_{max.}$ 560 mμ; spectra 2–6). Further additions yielded progressively more rhodopsin ($\lambda_{max.}$ 503 mμ), as shown by the shift of $\lambda_{max.}$ toward shorter wave-lengths (spectra 7–9)

in more detail, we need to comment upon the preparation of iodopsin.

Chicken retinas contain both cones and rods, in the ratio[15] of about 8 : 1. Hence the extraction of photosensitive pigments from dark adapted retinas always yields mixtures of rhodopsin and iodopsin[15,22]. However, Wald *et al.* showed that one can obtain from light-adapted chicken retinas mixtures of the colourless rod and cone opsins, which upon incubation with neo-*b* retinene in solution yield rhodopsin and iodopsin[15]. They showed further that chicken cone opsin has a much greater affinity for neo-*b* retinene than rod opsin, so that the addition of limited amounts of neo-*b* retinene (less than needed to combine with all the available cone opsin) results in the formation of iodopsin alone, uncontaminated with rhodopsin.

We have used this method of preparation, as illustrated in Fig. 10. In the experiment shown, the first five additions of neo-*b* retinene resulted in the synthesis of iodopsin alone, with $\lambda_{max.}$ 560 mμ (curves 2–6). Further additions led to the formation of rhodopsin ($\lambda_{max.}$ 503 mμ), as shown by the shift of $\lambda_{max.}$ toward progressively shorter wave-lengths (curves 7–9).

For the experiments described below, the mixed opsins (rod and cone) from 200–250 chicken eyes were extracted by the methods of Wald *et al.*[15], and a small aliquot of each new preparation was assayed as shown in Fig. 10. The opsin stock was then mixed with less neo-*b* retinene than would saturate the cone opsin (for example, 3·5 mμ mole neo-*b* per 0·2 ml. of the opsin preparation shown in Fig. 10), and the resulting iodopsin solutions were stored frozen at − 15° C. For use, they were thawed and mixed with equal or double their volumes of glycerol, depending on the temperature at which experiments were conducted. (This way of preparing iodopsin has the manipulative advantage of letting one work in white light until the retinene is added; only then need one shift to the dim red light required to avoid bleaching iodopsin[15,22].)

Fig. 11 shows the results of irradiating such an iodopsin preparation at − 20° C. (spectrum 1) with orange light. This converts it almost completely to meta-iodopsin, with $\lambda_{max.}$ about 500 mμ (spectrum 2). Meta-iodopsin is stable below about − 35° C., but even at temperatures as low as − 20° C. it hydrolyses slowly in the dark to all-*trans* retinene and opsin. The hydrolysis is speeded at higher temperatures. The sample shown in Fig. 11 had for this reason been brought to room temperature before measuring spectrum 3.

Since the absorption spectra of iodopsin and meta-iodopsin overlap only slightly, at appropriate wave-lengths one can irradiate the one with almost no effect upon the other. As shown in Fig. 11, irradiation at 610 mμ results in a virtually quantitative conversion of iodopsin to meta-iodopsin. Conversely, by irradiation at 450 mμ, one can convert a considerable fraction of meta-iodopsin back to iodopsin, as shown in Fig. 12. Moreover, this wide separation of the absorption maxima of iodopsin and meta-iodopsin enables one to identify them, when mixed, more easily than the vertebrate rhodopsins and meta-rhodopsins produced in comparable experiments (cf. refs. 2 and 3). Otherwise, these experiments raise no new issues that have not already been discussed for rhodopsin[2,3,13] (see also first and second communications).

When iodopsin is irradiated at lower temperatures than those used in the experiments of Figs. 11 and 12, it is converted only to lumi-iodopsin. This must be warmed above about − 45° C. before it changes to meta-iodopsin. The absorption spectrum of chicken lumi-iodopsin has the same shape as those of the other chromoproteins we have described (first and second communications), and its $\lambda_{max.}$ lies at about

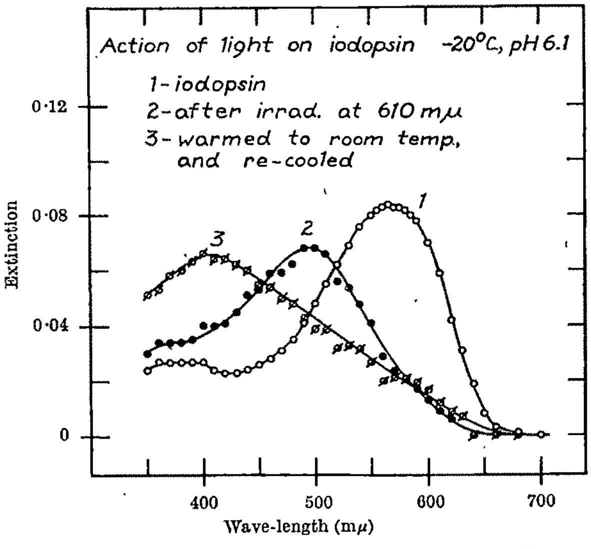


Fig. 11. Formation of meta-iodopsin, and its hydrolysis to retinene and opsin. Iodopsin in 1 : 1 glycerol–digitonin (*p*H 6·1) is cooled to − 20° C. (spectrum 1), and irradiated 20 min. at 610 mμ (half band-width 6 mμ). This converts almost all of it to meta-iodopsin, with $\lambda_{max.}$ about 500 mμ (spectrum 2). Upon warming to room temperature in the dark, the latter hydrolyses to retinene and opsin (spectrum 3)

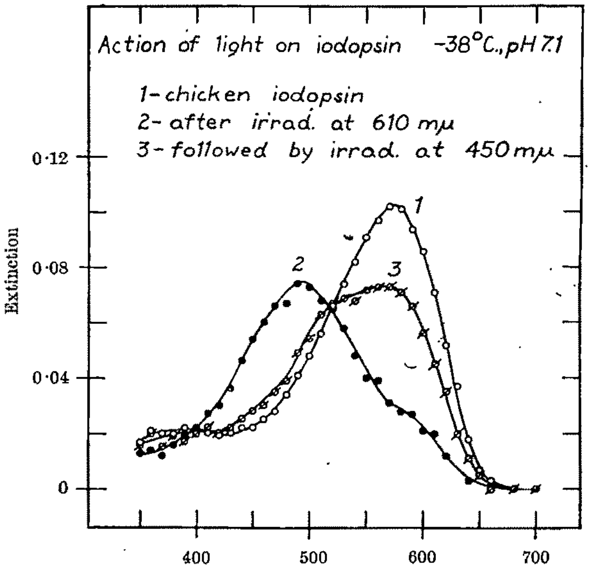


Fig. 12. Interconversions of iodopsin and meta-iodopsin. Iodopsin in 2 : 1 glycerol–digitonin (*p*H 7·1) is cooled to – 38° C. (spectrum 1) and irradiated 2 hr. at 610 mμ (16 mμ half band-width). This results in its partial conversion to meta-iodopsin (spectrum 2). The latter is now irradiated 20 min. at 450 mμ (same band-width), which converts a large fraction of it back to iodopsin (spectrum 3). Neither irradiation is sufficiently extensive to produce the steady-state mixture of chromoproteins (refs. 2 and 3). In this experiment, the temperature of the Beckman cell compartment was controlled (first communication) by circulating butyl 'Cellosolve' from a reservoir chilled with solid carbon dioxide

525 mμ. The isomeric 9-*cis* chromoprotein, isoiodopsin[15], on irradiation yields the same lumi- and meta-iodopsins as does iodopsin (cf. refs. 2 and 3).

We have made the surprising observation that the photosensitivity of iodopsin, that is, the quantum yield of photoisomerization from 11-*cis* to *trans*[2,3], decreases markedly as one lowers the temperature. (Compare, for example, the extent of conversion of iodopsin to meta-iodopsin in the experiment of Fig. 11, in which the irradiation lasted 20 min., with that shown in Fig. 12, in which the same type of irradiation was continued for 2 hr. at a higher intensity.) It is difficult to formulate this observation quantitatively, since the irradiation yields different products as one lowers the temperature. However, irradiating always at 610 mμ, and making approximate allowance for differences in the absorption spectra of the products—retinene, meta-iodopsin, and lumi-iodopsin—the effect is unmistakable. We have observed that the photosensitivity of the conversion of squid rhodopsin to alkaline metarhodopsin also decreases between + 5° and – 20° C., though the effect is considerably smaller than with iodopsin. However, we observe essentially no decrease in quantum efficiency when photoisomerizing neo-*b* retinene in the same solvent system (2 : 1 glycerol-digitonin) at + 20° and – 40° C. The decrease in photosensitivity on lowering the temperature therefore appears to be associated with the coupling of neo-*b* retinene as chromophore to opsin, particularly to cone opsin.

Discussion. The bleaching of rhodopsin and iodopsin by light proceeds over intermediates with similar chemical and spectroscopic properties (lumi- and meta-pigments) and results finally in the release of all-*trans* retinene and opsin. It is reasonable to assume that the photochemical and thermal reactions involve the same type of change in both classes of pigment—that in both the photochemical isomerization of the *cis* chromophore to the all-*trans* configuration is followed first by the thermal re-arrangement of opsin, then by the hydrolytic cleavage of the all-*trans* chromophore from opsin.

We have postulated that the configurational re-arrangement of the opsins from the lumi- to the meta-pigments is blocked at low temperatures by their structural rigidity and that of the solvent. It is tempting to speculate that this rigidity of the opsins also imposes configurational barriers which restrain the photoisomerization of the chromophore, and thus are responsible for the observed decrease in photosensitivity.

By analogy with the schemes proposed for the action of light on rhodopsins (first and second communications), we can summarize our observations with chicken iodopsin as follows :

Reaction	Product	Colour
	IODOPSIN (11-*cis*)	violet
1. Photochemical stereoisomerization of the chromophore	⇅	
	LUMI-IODOPSIN (all-*trans*)	purple
2. Thermal rearrangement of the opsin	↓	
	META-IODOPSIN (all-*trans*)	red
3. Hydrolysis of the chromophore from opsin	↓	
	RETINENE (all-*trans*) + OPSIN	yellow

The absorption maximum of chicken iodopsin lies at a considerably longer wave-length than those of the rhodopsins. We assume that this is due to stronger interactions (owing in part, perhaps, to a closer steric fit) between the neo-*b* chromophore and cone as compared with rod opsin[9]. The absorption properties of lumi- and meta-iodopsin, on the other hand, are not very different from those of the corresponding rod chromoproteins (first and second communications). This suggests that photoisomerization of the retinene chromophore to the all-*trans* configuration tends to equalize the degree of its interaction with rod and cone opsin.

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LETTERS TO THE EDITORS

GEOPHYSICS, ASTRONOMY and METEOROLOGY

Cosmic Radiation and the Weather

THE purpose of this communication is to point out the existence of a large tropospheric and stratospheric effect produced by the solar-cycle modulation of cosmic rays. Since there is some evidence for solar-cycle correlations in the weather, the phenomena described here should be considered in attempts to understand climatological effects of solar-cycle period.

The records of Forbush[1] for the ionization produced by cosmic rays at the ground show through two solar cycles in inverse correlation with solar activity; that is, if one compares sunspot numbers with cosmic-ray ionization at sea-level, it is found that high sunspot numbers are associated with low cosmic-ray ionization (see Fig. 1). Neher and Winckler[2,3] have shown that ion chambers at the top of the atmosphere show a very much larger modulation with the solar cycle than the instruments at sea-level. The change in ionization at 10 mb. is bound to be approximately a 50 per cent reduction between sunspot minimum and sunspot maximum. That this change in ionization is produced by a true cosmic-ray modulation was demonstrated by the study of primary cosmic-ray alpha-particles by Freier, Ney and Fowler[4], who found that the change in the flux of primary helium nuclei with energy greater than 200 MeV./nucleon was 50 per cent at the top of the atmosphere, in quantitative agreement with the ionization measurements of Neher and Winckler. Because the solar-cycle modulation changes the flux of low-energy particles more than the flux of high-energy particles, the change in the atmosphere due to ionization must show a latitude effect. (This effect is produced by the selective effect of the Earth's magnetic field on primary cosmic rays. For example, at the equator, in the vertical direction, only cosmic-ray protons of energy greater than 15 BeV. can reach the Earth, whereas at the magnetic poles cosmic rays of all energies can arrive.) The relation between cosmic-ray flux and atmospheric ionization is quite well understood, and it is therefore possible to construct a graph showing the percentage change in atmospheric ionization as a function of altitude and latitude. In order to do this, one combines the results of sea-level ion chambers and the balloon observations to give a profile of the ionization through the atmosphere.

Fig. 2 shows the result of using the cosmic-ray observations to determine the percentage change in world-wide ionization. The percentages plotted show the amount by which the ionization was reduced from 1954 (sunspot minimum) to 1957 (sunspot maximum). Note that the latitudes plotted are geomagnetic rather than geographic. The percentages are $\frac{I_{1954}-I_{1957}}{I_{1954}}\times$ 100, where I_{1954} represents the ionization in 1954, and I_{1957} that in 1957.

It can be seen from Fig. 2 that even in the troposphere a relatively large percentage change in the ionization occurs. If there is a connexion between atmospheric ionization and thunderstorm activity, for example, the solar-cycle modulation might be observed in the climatological data. A relation between ionization and weather

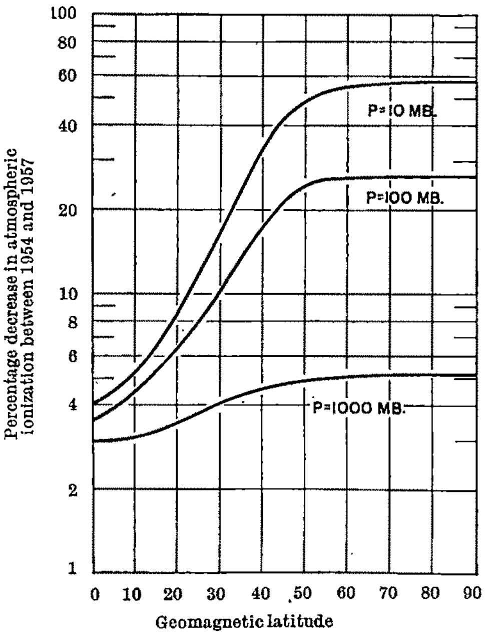

Fig. 2. Percentage reduction in atmospheric ionization during the last solar cycle. The percentage change is calculated with respect to the value of the ionization at sunspot minimum in 1954

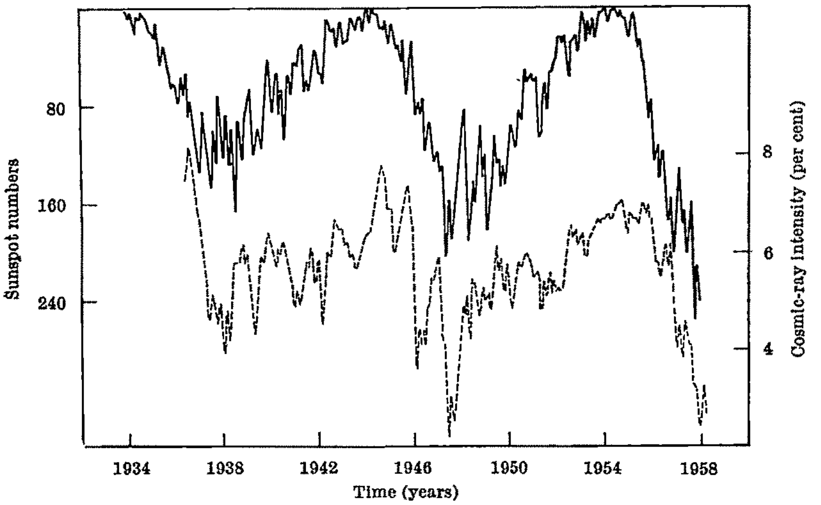

Fig. 1. Forbush's results ref. (1) showing the inverse correlation of cosmic-ray intensity and solar activity. ———, Sunspot numbers; – – – –, cosmic-ray intensity

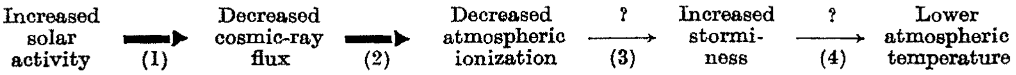
Increased solar activity
(1)
Decreased cosmic-ray flux
(2)
Decreased atmospheric ionization
?
(3)
Increased storminess
?
(4)
Lower atmospheric temperature

Fig. 3

has been previously postulated by Vonnegut. The known variations of cosmic rays may allow a test of such a hypothesis. In looking for climatological variations, a further point should be made about the cosmic-ray data. The two solar cycles measured so far show that the largest changes occur during one or two years near sunspot maximum. Because solar activity rises relatively rapidly from sunspot minimum to sunspot maximum, differences produced by ionization should be great between 1954, 1955 (sunspot minimum) and 1957 (sunspot maximum). In looking for correlations over long periods of time, the most easily available index of the cosmic-ray ionization is the sea-level ion-chamber data at the equator (Huancayo), and the high-latitude ionization and neutron measurements of Fenton and Rose[5]. This should be one variable in any correlation study of this problem.

The cosmic-ray changes observed by Forbush and the calculated changes in ionization rest on firm ground. It is perhaps worth speculating on the kind of climatological effects the change in ionization might produce. It should be pointed out, however, that what follows is speculation and is included here only to suggest possible climatological variables to study.

If one assumes a connexion between ionization and storminess, for example, one might also expect a correlation of Earth temperature and the sunspot cycle. It seems reasonable to postulate that a lowered conductivity of the air (making it a better insulator) might enhance the build-up of electric fields and thereby increase storminess (at least thunderstorms). The increased cloud cover associated with the storms would produce radiation cooling of the Earth and a lower mean temperature at sunspot maximum. One might therefore account qualitatively for Humphrey's paradox of the 'hot sun and the cool Earth'. The suggested chain of events is shown diagrammatically above in Fig. 3.

The heavy connecting arrows show the established relations (1) and (2). The question mark on step (3) shows the speculative connexion between ionization and storminess. Relation (4) is also shown with a question mark, because it does not rest on firm observational grounds as do (1) and (2).

Obviously the chain of events suggested is just an example, and climatologists should be able to construct many such possible patterns which could be tested against the cosmic ray-variation of weather hypothesis.

In summary, it should be emphasized that the meteorological variable subject to the largest solar-cycle modulation in the denser layers of the atmosphere (that is, at pressures greater than 1 mb.) is the atmospheric ionization produced by cosmic rays. It seems, therefore, worth while to investigate the possible effects of the change in this variable in climatology.

EDWARD P. NEY

University of Minnesota,
Minneapolis 14, Minnesota.

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Measurement of Horizontal Displacement along Faults in the Ocean Floor

IN the eastern Pacific Ocean a right lateral displacement of 84 nautical miles along the Murray Fracture Zone[1] has been suggested by a total magnetic intensity survey[2,3]. The Pioneer Ridge, a newly found east–west fault located between the Mendocino and the Murray Fractures along 38° 30′ north latitude and known to extend between 127° and 136° west longitude, was surveyed by the R.V. *Horizon* of the Scripps Institution of Oceanography of the University of California for the express purpose of measuring the direction and the amount of horizontal slip. A left lateral displacement of 138 nautical miles was found.

The method of measurement depends on the fortunate fact that the magnetic anomaly pattern of the ocean floor revealed by surveys which extend from 32° to 41½° N. lat. and from 125° to 135° W. long., is characterized by north–south trending features with a relief of several milligauss. The two lower curves in Fig. 1 are 15 miles apart and show the north–south alignment of the magnetic pattern. The east–west fractures cut across this pattern so that horizontal slip along a fracture produces a displacement. This is shown in Fig. 1 by a comparison of the uppermost profile taken north of Pioneer Ridge with the lower pair taken to the south. The uppermost profile is roughly 70 miles north and far to the west.

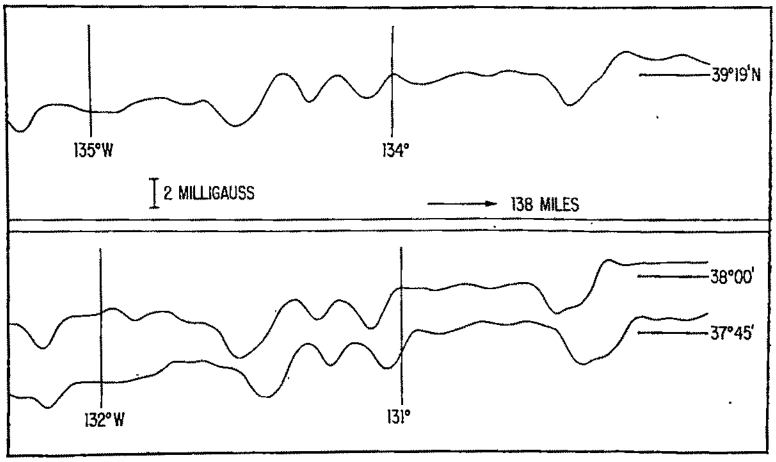

Fig. 1. Profiles of total magnetic intensity on both sides of, and parallel to, the Pioneer Ridge Fault, showing left lateral slip of 138 nautical miles

A left lateral fault with a displacement of 138 nautical miles is required to match the pattern. The goodness of fit shows that the amount of distortion accompanying this left lateral slip over a length of 90 miles was less than 10 per cent and implies a remarkable freedom of movement of one crustal block with respect to the other.

The measured displacements along the Murray Fracture Zone and the Pioneer Ridge reveal an unsuspected mobility of small blocks of oceanic crust.

This work was sponsored by the U.S. Office of Naval Research under Contract No. 2216(05).

VICTOR VACQUIER
University of California
Marine Physical Laboratory,
Scripps Institution of Oceanography,
San Diego 52, California. Dec. 30.

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Planetary Nebulæ in the Large Magellanic Cloud

PLANETARY nebulæ have been found in the Andromeda Nebula[1] and in the Small Magellanic Cloud[2]. A new catalogue of emission objects in the Small Cloud to be published shortly by me contains nearly six hundred objects; fifty-three of these are planetary nebulæ. Using the Armagh–Dunsink–Harvard telescope and prism with 103*a.E* red-sensitive plates exposed through a red filter, a planetary nebula is readily recognized by a single H_α emission line with no continuum and not associated with nebulosity.

This method has now been applied to the Large Magellanic Cloud. The observational programme is not quite completed and the plates taken have been only provisionally examined. Nearly one thousand emission objects have been found on these plates; at least 120 of these are planetary nebulæ. Where blue-sensitive prism plates are available and the objects are bright enough confirmation as planetaries is provided by the N_1 N_2 nebular lines of O III. The presence of planetary nebulæ presents additional evidence of Population II objects in the Large Cloud.

E. M. LINDSAY
Armagh Observatory,
Northern Ireland. Dec. 30.

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Rotational Structure of the 3914 A. N_2^+ Band in Sunlit Auroræ

ON the evenings of September 3 and 4, 1958, striking sunlit auroræ were observed from Saskatoon in the western sky. Although no photographs were taken, there can be no doubt about the nature of these displays because they showed the divided rays with greyish-coloured upper segments as described by Störmer[1], and because of the peculiarities of the spectrum. During each night of the display a plate was obtained with an *f*/0·8 Schmidt grating spectrograph having a dispersion of 40 A./mm., while a third plate was obtained from the displays of both nights with a large *f*/0·8 spectrograph having a dispersion of 20 A./mm. They were set to record the spectrum in the 3500–4500 A. region and the lines of sight of the instruments were directed towards the upper parts of the rays.

The lower dispersion spectra show unusually high relative intensities of the first negative N_2^+ bands for higher vibrational levels; this effect was first observed by Störmer and explained by Bates[2] as due to an abnormal distribution of the populations of the vibrational levels of N_2^+ resulting from the fluorescent excitation process dominant in sunlit auroræ. All three plates showed a most unusual intensity distribution in the fine structure of the 0,0 N_2^+ band at 3914 A. A microphotometer tracing of this band as photographed on the high dispersion plate is shown in Fig. 1*a*. For comparison a tracing is shown of the band from a normal aurora in Fig. 1*b*. The band from sunlit auroræ is developed to very high rotational quantum numbers, and its intensity distribution is not quite uniform from line to line. The lines of the *P* branch have crossed the zero gap and underlie the beginning of the *R* branch. The rotational temperature derived from the band by plotting log (I/K') against $K'(K' + 1)$ was 2,100° K. The perturbation at the line $R(38)$ is clearly visible.

There are two possible mechanisms which might explain the high rotational temperature. First, the N_2^+ ions might be in radiative equilibrium with the sunlight; this is an extension of Bates's explanation to cover rotational as well as vibrational degrees of freedom. Second, the N_2^+ ground-state might have a rotational distribution corresponding to thermal equilibrium at some high temperature, which might or might not be the temperature of the atmosphere at the height concerned. In either case, as was pointed out by Swings[3], the presence of Fraunhofer lines in the exciting sunlight would cause the distribution of line intensities to be non-uniform, just as in the spectra of comets[4,5]. The N_2^+ molecule, being homonuclear, has no rotation or vibration-rotation spectra, so that radiative equilibrium would be established easily if collisions were not important. If the first case is to be treated properly, absorption and emission in the *P* and *R* branches of all the bands of the system must be considered at once; for the second case only the absorption is important, but some of the higher bands may still contribute since the vibrational excitation is unusually high.

The exciting intensities were estimated from the Utrecht Atlas of the solar spectrum[6] as fractions of the continuum; the continuum was considered as having a colour temperature of 7,150° K. as recommended by Minnaert[7]. The first case was treated approximately by including the (0,0) and (0,1) bands which should be the most important; their shares of the excitation are in the ratio of about 3 : 1. For the second case only the (0,0) band was included. It would be expected that inclusion of more bands would tend to smooth out the distribution of intensities obtained. The general trend of the two sets of results was very similar, but there were considerable differences in detail and the second case gave better agreement with the observations. The temperature used was 2,100° K., as described above; the agreement of the calculated and observed spectra confirmed it.

We conclude that the N_2^+ ions observed had a rotational temperature in the ground-state of 2,100° K. There seems to be no way of deciding whether this is also the temperature of the atmosphere at the height observed, except perhaps from the fact that the ions do not seem to be in radiative equilibrium with the sunlight. It is conceivable that the high temperature

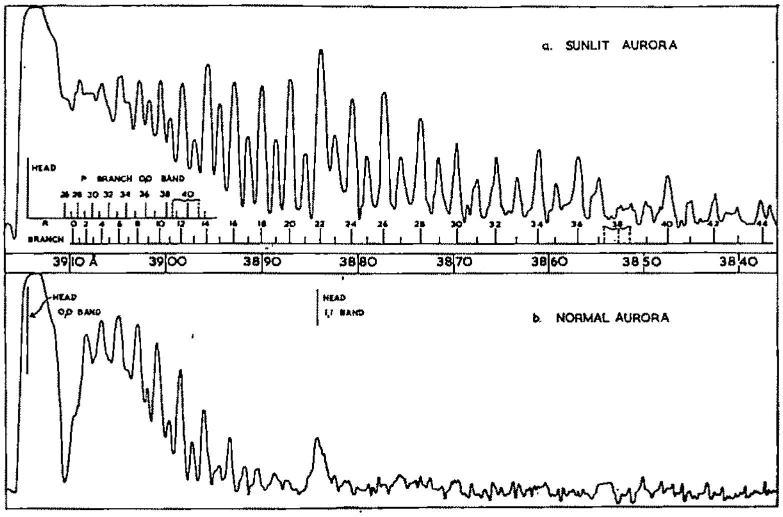

Fig. 1

could result from this mechanism, but that the distribution among the levels would be smoothed by collisions without lowering the temperature. This seems rather unlikely, especially if many of the collisions are with N_2, since charge-exchange can reduce the rotational temperature to the ambient in a single collision. It is at least possible that this observation shows a kinetic temperature of 2,100° K. at a height which is likely to be in the range 300–600 km.

The investigation reported here has been sponsored by the Geophysics Research Directorate of the U.S. Air Force, Cambridge Research Center, Air Research and Development Command, under contract 19(604)-1831.

D. M. Hunten
H. J. Koenig
A. Vallance Jones

Physics Department,
University of Saskatchewan,
Saskatoon, Canada. Dec. 11.

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PHYSICAL SCIENCES

Wear of Graphite Surface by Punching and Planing

The wearing process has been studied in detail on graphite basal plane surfaces rubbed by metallic micro-probes while being observed with a microscope having epi-illumination. When the graphite was smooth and flat, the probe under very light force could be passed repeatedly over the graphite without damage. Under increasing normal force, however, the surface showed a few sharp shadow lines extending away from the contact region, and these were interpreted as boundaries of stress or dislocation within the crystal.

Upon sustaining the contact pressure at a site showing such lines, by stopping the motion, it was found that the basal plane surface sometimes collapsed locally, in time-dependent manner. Instantaneously with the collapse the lines disappeared, and a tiny scar was found when the probe was moved away.

The scars were very shallow and in appearance resembled a hole in a skating rink with chips lying at the borders. It was evident that a graphite fragment had been punched out of a basal plane layer, and remained tilted against it if not completely pushed aside. When the probe was slid away from a scar, a wear track almost invariably began at the first pass and continued without diminishing.

These wear tracks were characteristically uniform in width and depth so that long straight lines of ruled geometry were easily drawn. The debris in the form of thin platelets was rather cleanly swept to the borders of a track and could sometimes be fitted back into it.

This type of wear was seen to occur through a planing of the basal plane surface. It appeared that the metallic probe itself could produce the wear track by penetration of the basal plane at the scar, or that the probe could trap a graphite fragment from the scar, which fragment then served as a secondary tool for the planing. It is easily imagined that the edges of such a fragment would tend to engage the opened edges of the scar so that a continuous wearing process would inevitably follow.

Wear by planing also started when the probe passed from smooth basal plane surface across a step (in the range 10^{-4}–10^{-5} cm. height), either upward or downward. In the first instance the basal plane was penetrated directly by passage of the probe against the riser of the step. In the second instance the probe usually produced a fragment by local collapse of the edge of the step under pressure at the descent. In both instances a continuous wearing process followed.

In these instances of wear by planing, the graphite surface was continuously delaminated by the tool. A characteristically different wearing process, also in the graphite basal plane, will be called 'peeling', and will be described in a later publication.

Robert H. Savage

General Electric Research Laboratory,
Schenectady, New York. Jan. 14.

Metallic Conduction in the Crystal Compounds of Graphite

A marked increase of electrical conductance on forming crystal compounds of graphite with bromine, and even more with alkali metals such as potassium, has been previously attributed to electron transfer between the carbon hexagon networks, acting as amphoteric macro-aromatic molecules, and the intercalated atoms[1]. It was further suggested that the bonds between these macro-aromatic molecules and atoms such as potassium were metallic in character. Existing evidence indicated that electron transfer is less complete than when salts are formed with systems more strongly electro-negative than the carbon macromolecules (cf. also ref. 2). However, development of this interpretation has been hindered by the need to experiment with polycrystalline graphite, either as powder or in compacted forms[3].

Recently, we have been able to carry out experiments on pieces of graphite in which the preferred orientation of the carbon hexagon networks is so good that the results permit definite inferences about the behaviour of single crystals, and in particular about the anisotropy of the electronic properties along the *a*- and *c*-axes of graphite. By courtesy of the Morgan Crucible Co., pieces of 'columnar' graphite have been made available in which individual crystallites show excellent alignment of their *a*-axes parallel to the columnar axis, though their *c*-axes are disordered radially. By developing a method of depositing graphite by cracking methane[4], we have also had available pieces of graphite in which individual crystallites show excellent alignment of their *a*-axes parallel to a plane, and of the *c*-axes normal to it. Pieces of these materials several millimetres across in all dimensions have been mounted between 4-point platinum electrodes, so as to measure the electrical resistance parallel to the *a*-axis and parallel to the *c*-axis of the crystallites in the highly oriented material. Preliminary selection permitted the use of graphite with *a*-axis specific resistance as low as $3 \cdot 6 \times 10^{-5}$ ohm cm. (columnar natural graphite) and $4 \cdot 75 \times 10^{-5}$ ohm cm. (pyrolytic graphite). Furthermore, the specific resistivity in the *c*-axis of all samples of pyrolytic graphite was high, about 0·5 ohm cm. These values may be compared with previous direct determinations on very small single crystals[5]. A further test of the absence of serious crystal defects in the specimens now used was the measured temperature coefficient of resistance. With the best samples, this was always positive over the range 80–670° K. in the *a*-axis. In the *c*-axis direction of pyrolytic samples the temperature coefficient of resistance was negative.

It was found that because of the excellent alignment, these specimens could take up adducts such as bromine, iodine monochloride, or potassium, up to the limiting values characteristic of the most highly charged crystal compounds, without cracking due to uneven expansion of individual regions in the specimen. By suitable methods, practically all the adduct could be removed again, with recovery of the specimen. This could be treated in various cycles of crystal compound formation and decomposition while actually mounted in the jig used for resistance measurements.

Changes of conductance now found on forming crystal compounds of graphite can be referred to specific directions in the crystal. For compactness, *relative* changes *R*(crystal compound) / *R*(graphite) are recorded in Fig. 1. The values refer to room temperature but the temperature coefficients are small.

It will be seen that formation of the crystal compound leads to a marked decrease of resistance in the *a*-axis direction parallel to the planes of carbon hexagon networks. This accords with the previous interpretation that the conduction bands of the aromatic macro-molecules accept electrons from the potassium, and probably donate electrons to the bromine. However, the use of our highly oriented specimens of graphite permits the further conclusion that in this direction in the crystal the changes for the different crystal compounds are comparable in order of magnitude, with a reduction factor of about 10 in each case (Fig. 1).

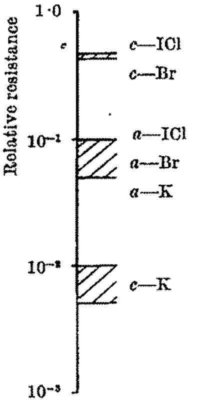

Fig. 1

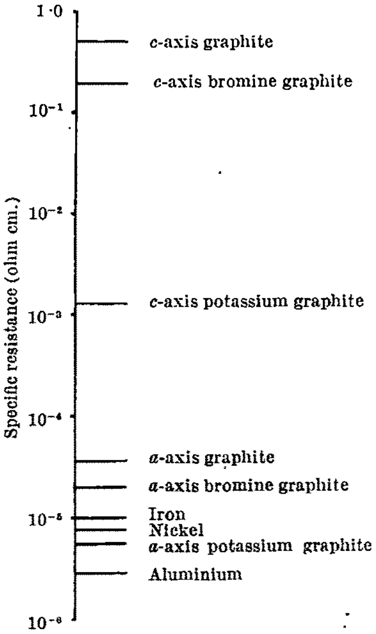

Fig. 2

Fig. 1. Relative change of resistance in *a*- and *c*-axis directions on forming crystal compounds of graphite

Fig. 2. Comparison of resistivity of well-aligned graphite and its crystal compounds with that of some metals

In the direction perpendicular to these networks, the decrease in resistance is even more striking. For the bromine and iodine monochloride adducts, only a small reduction factor (about 2) is observed. For potassium, on the other hand, the reduction factor is about 100–200. This relatively enormous increase in electrical conductance accords well with the view that the potassium atoms form 'quasi-metallic' bonds with the aromatic macromolecules in the crystals; these permit metallic conduction paths in the direction of the *c*-axis as well as those already present in the direction of the *a*-axis. The change to a more positive temperature coefficient lends further support to this view.

Tentatively, the much lower increase in *c*-axis conductance of graphite/bromine may be related with its different crystal structure. In potassium/graphite, C_8K (ref. 6), alkali metal atoms enter every layer and can thus form continuous metallic paths. In graphite/bromine, C_8Br, only alternate layers between the hexagon networks are occupied by the bromine (ref. 7). Thus, conduction paths are separated by a single Van der Waals repulsion distance from one another. This kind of solid conductor is comparatively novel electronically and may prove to exhibit other properties by means of which our tentative interpretation may be tested. For graphite/iodine monochloride it is not yet certain whether the adduct enters every layer or alternate layers[8]. The present resistivity would suggest that the structure is in fact similar to that of bromine/graphite.

It seems worth adding that the increases of conductance with the highly oriented specimens now available make potassium/graphite in the *a*-axis directions rather better than nickel as a conductor of electricity (Fig. 2). Other adduct atoms are being tested to see how far the nature of the adduct affects the increase of metallic conduction attainable; this may be expected to depend both on the adduct and the shape of the conduction bands in the parent material used.

We wish to acknowledge the support given by the Electricity Council to this research.

A. R. Ubbelohde
L. C. F. Blackman
J. F. Mathews
Imperial College of Science and Technology,
London, S.W.7.
Jan. 21.

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X-Ray Diffraction Measurement of Radiation Damage in Stretched Rubber

Bopp and Sisman[1] have mentioned that X-ray diffraction revealed a loss of crystallinity in a specimen of natural rubber irradiated to 10^7 r. in a reactor while stretched 300 per cent. During a study of radiation damage to elastomers, we have also observed the extreme sensitivity of stretched rubber to radiation.

5/32-in. sections of rubber specimens were stretched 500 per cent, exposed to a high irradiance of 1,000 kVp. X-rays until ruptured and periodically assessed for stress relaxation as manifested by diminished X-ray diffraction intensities.

An experimental mill-mixed rubber was used which was capable of sustaining a high stress without relaxation. Its composition, by weight, was as follows: deproteinized pale crepe, 100; sulphur, 2; zinc oxide, 3; zinc dibutyldithiocarbamate, 0·25; 2-mercaptobenzothiazole, 0·4. It was cured for 20 min. at 138° C. Specimens consisted of strips 10 mils thick and 1·3 in. wide, and were degassed *in vacuo*.

The stretched specimens were held by two Hoffman-type screw clamps mounted on a metal frame. They were firmly fixed by sandwiching between two aluminium plates, 1/16 in. thick, screwed to the frame. An aperture 1 cm. × 1 cm. in the plates exhibited the centres of the specimens for study.

Irradiations were carried out in an atmosphere of nitrogen with the General Electric Co. 'Resotron-1000' operated at 3 m.amp. and 1,000 kVp. Ferrous sulphate dosimetry showed an absorbed dose-rate of $2 \cdot 4 \times 10^5$ r./hr.

X-ray diffraction patterns were taken with the General Electric Co. *XRD*-3 Geiger-counter spectrometer. Instrumental conditions included a forward reflexion arrangement with the specimen aperture over the goniometer pivot, using copper $K\alpha$ radiation with a 3-deg. beam slit, Soller slit, 0·05-deg. detector slit scanning 2θ at 0·2 deg. per min., and nitrogen currents past both sides of the specimen.

When the specimens were arranged with the direction of stretch horizontal, the Geiger counter scanned the amorphous halo along the X-axis shown in the pre-irradiation pinhole diagram in Fig. 1. With the direction of stretch vertical, the counter scanned the diffraction spots and the halo between them along the Y-axis. An amorphous halo pattern was obtained by subtracting the spectrometer chart pattern for air-scatter from one for a specimen stretched in the horizontal direction. A diffraction spot pattern was obtained by subtracting a spectrometer chart pattern for a specimen stretched in the horizontal direction from the corresponding one for a vertical direction of stretch. The amorphous halo ran snugly between the diffraction spots of interest (Fig. 1) and added its outer shoulder intensities significantly to the intensities of the diffraction spots. The subtraction removed the influence of the amorphous halo and also the influence of air-scatter, since this was a constant factor. The diffraction spot pattern obtained by the subtraction represents the composite or 'average' of patterns produced by two rectangular areas of specimen, both having dimensions 5 mils × 375 mils and being centred in the sample-holder aperture with the long side vertical, since the defining aperture of the detector slit was vertical and had these dimensions. One specimen area was presented by a horizontal direction of stretch and had its long side perpendicular to the stretch, while the other area was presented by a vertical direction of stretch and had its long side

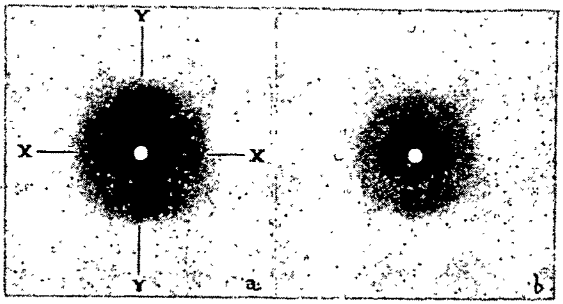

Fig. 1. X-ray diagrams of stretched rubber showing a loss of diffraction intensity upon irradiation: *a*, before irradiation; *b*, after $1 \cdot 85 \times 10^6$ r. absorbed dose

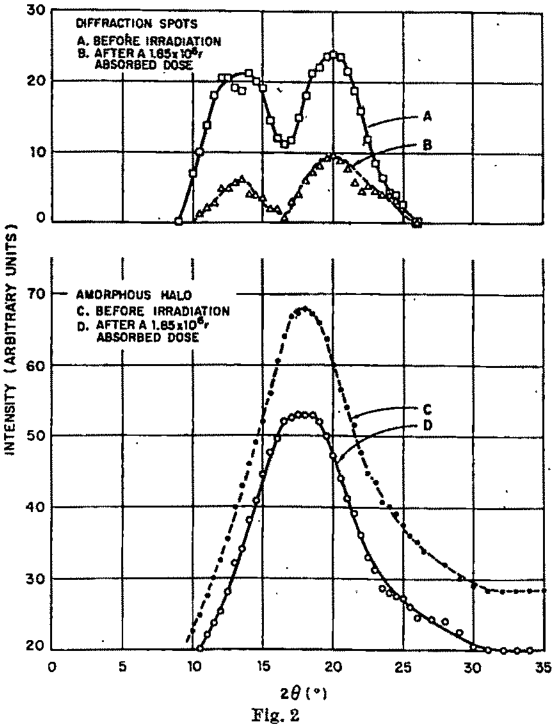

Fig. 2

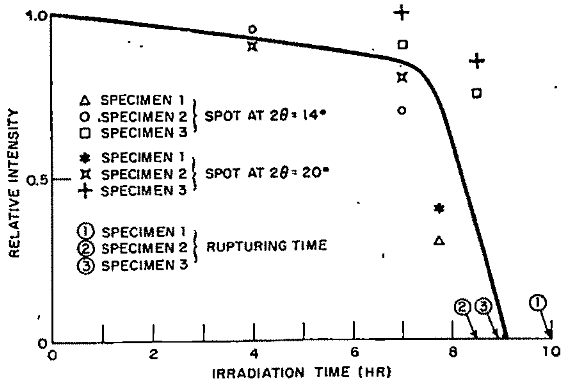

Fig. 3. Decrease in diffraction spot intensity (peak value) versus irradiation-time

parallel to the stretch. The halo intensities of these areas may have differed somewhat, and the diffraction spot pattern obtained by the subtraction is considered to be a semi-quantitative diffraction view of the specimen, useful for following and comparing radiation damage in rubber.

Stretched rubber is extremely sensitive to radiation damage, manifested by stress relaxation with attendant changes in X-ray diffraction intensity (Fig. 1) and early rupture. The average rupturing dose for three specimens was $2 \cdot 2 \times 10^6$ r.

Fig. 2 shows diffraction patterns for spots and halo for a specimen before irradiation and after a nearly rupturing dose of $1 \cdot 85 \times 10^6$ r. The changes suggest specimen thinning and conversion of some crystalline domain to amorphous. Diffraction intensity is extremely sensitive to thickness with very thin specimens of rubber. Hypothetically, if loss in spot intensity were due solely to thinning without any conversion of crystalline to amorphous domain, the spot and halo intensities would be decreased by the same percentage. If additionally an appreciable change from crystalline to amorphous domain occurred, the halo intensity would be reinforced appreciably, and the net result would be a percentage decrease in spot intensity greater than that of the halo. Fig. 2 displays this disparity.

Stress relaxation and attendant loss of diffraction spot intensity were detectable only after a significant lapse of time after initial irradiation. Fig. 3 shows the rate at which the maximum spot intensities decreased, and shows a detectable decrease after about 4 hr., which represents about 50 per cent of the rupturing dose.

It is believed that chain scission dictates the physical–mechanical radiation behaviour of stretched rubber. Stress relaxation would make scissions irreversible and their increase would soon weaken the specimen to the point when the chains slip and rupture of the specimen occurs. Cross-linking undoubtedly occurs simultaneously, but at too slow a rate to prevent destruction of the specimen. The extremely low doses which caused rupture in stretched specimens do not produce detectable physical–mechanical changes in unstretched rubber where cross-linking predominates.

WESLEY E. SHELBERG
LEWIS H. GEVANTMAN

U.S. Naval Radiological Defense Laboratory,
San Francisco 24, California.

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CHEMISTRY

Behaviour of Dicobalt Octacarbonyl at Elevated Temperature and Carbon Monoxide Pressure

WHILE studying the dissociation of dicobalt octacarbonyl ($Co_2(CO)_8$), we found that at certain pressures and temperatures 1 mole of carbon monoxide was absorbed per mole of the compound. On increasing or lowering the temperature the absorbed carbon monoxide was given off.

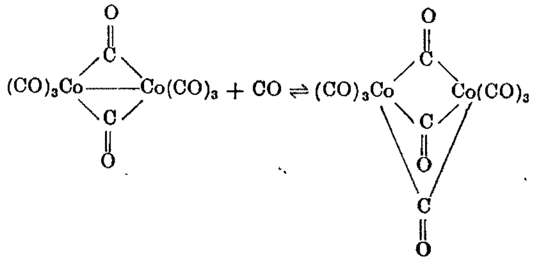
In a typical experiment, an autoclave provided with a heating mantle was charged with 77·4 gm. (226 m.mol.) of dicobalt octacarbonyl, the autoclave was pressured with carbon monoxide to 277·3 atm. at 28° C., and then was slowly heated to a certain temperature. To ensure equilibrium conditions, pressures were recorded only after temperature and pressure had remained constant for several hours. The differences between theoretical and observed pressure at various temperatures, expressed in moles of carbon monoxide absorbed per mole of dicobalt octacarbonyl, are given in Table 1.

Table 1

Moles of carbon monoxide absorbed per mole of dicobalt octacarbonyl	0·496	0·646	0·765	0·918	1·035	0·925
Temperature (° C.)	100	130	145	160	185	210
Observed pressure in atmospheres	342	362	373	378	393	425

The calculations are based on published compressibility data[1] and on the fact that the free space of the autoclave (after addition of dicobalt octacarbonyl) was 167 ml. The calibration of the pressure gauge permitted readings with an accuracy of ± 0·3 atm. After each reading the autoclave was allowed to cool to room temperature and the pressure then was recorded. The amount of carbon monoxide which remained absorbed at 28° C. and 272·2 atm. was found to be 0·095 mole of carbon monoxide per mole of dicobalt octacarbonyl.

It is unlikely, on the basis of molecular orbital considerations, that the uptake of carbon monoxide by dicobalt octacarbonyl is due to the formation of a dicobalt nonacarbonyl complex ($Co_2(CO)_9$):



Such a complex is structurally analogous to, but contains two more electrons than, iron enneacarbonyl ($Fe_2(CO)_9$). These two electrons would have to occupy the antibonding A_{1u} orbital[2] and thereby destabilize the complex.

A more plausible explanation of the uptake of carbon monoxide is to assume dissociation into a carbonyl cation and an anion:

$$CO + Co_2(CO)_8 \rightleftharpoons [Co(CO)_5]^+ + [Co(CO)_4]^-$$

In both ions cobalt has a stable rare-gas configuration. The dissociation of dicobalt octacarbonyl induced by carbon monoxide is entirely analogous to that induced by strong bases (B)[3,4]:

$$B + Co_2(CO)_8 \rightleftharpoons [BCo(CO)_4]^+ + [Co(CO)_4]^-$$

It is possible that other binuclear carbonyls such as manganese decacarbonyl ($Mn_2(CO)_{10}$) will behave similarly:

$$CO + Mn_2(CO)_{10} \rightleftharpoons [Mn(CO)_6]^+ + [Mn(CO)_5]^-$$

This finding may lead to a clearer understanding of the mechanism involved in certain reactions catalysed by metal carbonyls[4,5].

We wish to thank Prof. H. H. Jaffe of the University of Cincinnati for helpful discussions.

Sol Metlin
Irving Wender
Heinz W. Sternberg*

U.S. Bureau of Mines,
Central Experiment Station,
Bruceton, Pennsylvania.
Dec. 29.

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* Present address: 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

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Polarography of Pentacyanocobaltate(III) Complexes

The cobalt(III) complexes of pentacyano-type, $[Co(CN)_5X]$, including several kinds of the new complex compounds, $K_3[Co(CN)_5Cl]$, $K_3[Co(CN)_5SCN]$, $K_3[Co(CN)_5N_3].2H_2O$, $K_3[Co(CN)_5NO_2]$ and $K_4[Co(CN)_5SO_3].2H_2O$, have been studied polarographically. The pentacyano complexes were found to be divisible into two groups from the point of view of their polarographic behaviour. The ions of one group, $[Co(CN_5Cl]^{3-}$, $[Co(CN)_5Br]^{3-}$, $[Co(CN)_5I]^{3-}$ and $[Co(CN)_5SCN]^{3-}$, were reduced irreversibly in two steps to cobalt(I) complexes, through the cobalt(II) state at the dropping mercury electrode in potassium halide supporting electrolyte (Table 1). The ratio of the height of the first wave to that of the second is approximately 1 : 1.

Table 1. The Half-wave Potentials of Halogeno- and Thiocyanato-pentacyano Complexes.

The concentration of the complex ions was 0·005 *F*, temperature, 25° C. The results for the halogeno complexes were obtained in the presence of 0·0032 per cent 'Tween-80', since all the second waves had the small maxima except in the case of the thiocyanato complex

Complex	$E_{1/2}$ of first wave Co(III) → Co(II) (V. vs. S.C.E.)	$E_{1/2}$ of second wave Co(II) → Co(I)	Supporting electrolyte
$K_3[Co(CN)_5Cl]$	−0·86 V.	−1·20 V.	3 *F* KCl
$K_3]Co(CN)_5Br]$	$-0{\cdot}71_5$	−1·18	3 *F* KBr
$K_3[Co(CN)_5I]$	−0·71	−1·13	3 *F* KI
$K_3[Co(CN)_5SCN]$	−0·78	$-1{\cdot}23_4$	1 *F* KCl

The ions of the other group, $[Co(CN)_5N_3]^{3-}$, $[Co(CN)_5S_2O_3]^{4-}$, $[Co(CN)_5NO_2]^{3-}$ and $[Co(CN)_5SO_3]^{4-}$, were reduced irreversibly in one step to cobalt(I) complexes (Table 2). The height of the wave for the ions of the latter group is almost equal to the total height of the waves for the ions of the former at the same concentration (Fig. 1).

The currents are completely controlled by diffusion with respect to all the pentacyano complexes. The diffusion current and the concentration of the complex ion are linearly related at the concentration in the range $10^{-2} \sim 5 \times 10^{-4}\,F$ (expressed as the 'formality', namely, the number of gram formula weights per litre of solution—cf. ref. 1).

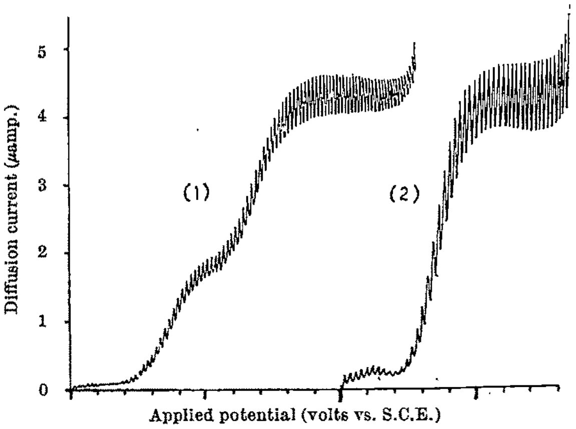

Fig. 1. Typical polarograms of pentacyano complexes obtained at the concentration of 0·001 *F*. Sensitivity: 1 : 80. (1) $[Co(CN)_5Cl]^{3-}$, in the presence of 0·0032 per cent 'Tween-80' (polyoxyethylene sorbitan mono-oleate). Supporting electrolyte: 3 *F* potassium chloride, from −0·5 V. (2) $[Co(CN)_5NO_2]^{3-}$, supporting electrolyte; 1 *F* potassium chloride, from −1·0 V. (versus S.C.E.), 100 mV./absc.

The half-wave potentials of the first waves for the ions of the former group are in the range $-0{\cdot}7 \sim -0{\cdot}9$ V. (versus the saturated calomel electrode), in potassium halide-supporting electrolyte, whereas those of the ions of the latter are in the range $-1{\cdot}2 \sim -1{\cdot}6$ V. (versus the saturated calomel electrode). On the other hand, for most of the usual cobalt(III) complexes, which are reduced to the metal through the cobalt(II) state, for example, ammine complexes, the half-wave potentials of the first waves are in the range +0·7 V. to −0·7 V. (versus the saturated calomel electrode)[2]. Thus the pentacyano complexes are very stable with respect to polarographic reduction. This is considered to be due to the stabilization of the complexes by the strong π-bond character in the bond between cobalt(III) and CN^-, that is to say, the co-ordinating bond is to be expressed by the formula $Co{=}C{=}N^-$ rather than by $Co{-}C{\equiv}N$. Accordingly, the stable existence of the oxidation state, + 1, in the polarographic reduction is not considered to belong only to the pentacyano complexes[3].

The polarographic stability of the pentacyano complexes increases in the following order of the ligand, *X*:

$$Cl^-, Br^-, I^-, SCN^- < N_3^- < S_2O_3^{2-} < NO_2^- < SO_3^{2-} < CN^-$$

As regards the reduction processes of the pentacyano complexes, they are believed to be as follows. For the ions of halogeno- and thiocyanato-complexes:

$$[Co(CN)_5X]^{3-} + e^- \rightarrow [Co(CN)_5X]^{4-} \qquad \text{1st step}$$
$$[Co(CN)_5X]^{4-} + e^- \rightarrow \text{Co(I) complex} \qquad \text{2nd step}$$

Table 2. The Half-wave Potentials of Azido-, Thiosulphato-, Nitro- and Sulphono-pentacyano Cobaltate(III) Complexes. Supporting electrolyte, 1 *F* potassium chloride; temperature, 25° C. The concentration of complex ions was 0·005 *F*.

Complex	$E_{1/2}$ of the wave, Co(III) → Co(I) (V. vs. S.C.E.)
$K_3[Co(CN)_5N_3).2H_2O$	$-1{\cdot}37_3$*
$K_4[Co(CN)_5S_2O_3]$	−1·29
$K_3[Co(CN)_5NO_2]$	$-1{\cdot}33_5$
$K_4[Co(CN)_5SO_3].2H_2O$	$-1{\cdot}53_5$
$K_3[Co(CN)_6]$	No reduction wave

* This result was obtained in the presence of 0·0064 per cent 'Tween-80'. The wave of the ion $[Co(CN)_5N_3]^{3-}$, which precedes that of the ion $[Co(CN)_5S_2O_3]^{4-}$, in the absence of the maximum suppressor, is shifted towards the negative direction of potential due to the presence of the maximum suppressor, 'Tween-80'.

For the ions of azido-, thiosulphato- nitro- and sulphono-complexes:

$$[Co(CN)_5X]^{(2+n)-} + 2e^- \rightarrow Co(I)\ complex$$

The structure and the co-ordination number of the cobalt(I) complex are not known at present, though efforts are now being made to isolate the complex in a solid state from the solution.

NOBUFUMI MAKI
JUNNOSUKE FUJITA
RYUTARO TSUCHIDA

Laboratory of Inorganic Chemistry,
Faculty of Science,
Osaka University,
Kita-ku, Osaka.
Oct. 21.

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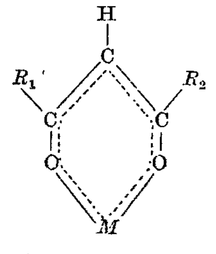
Metal – Oxygen Stretching Frequencies in the Metal Chelate Compounds of β-Diketones

RECENTLY, many papers[1] have been published on the infra-red spectra of metal chelate compounds of β-diketones in the sodium chloride (4,000 ~ 650 cm.$^{-1}$) region. The empirical assignments of the observed bands have also been made by Lecomte and other workers[2]. Since the CO stretching bands can be identified without much ambiguity, attempts have been made to correlate their frequencies with the stability of the chelates[3] or the ionization potential[4] of various metals.

It is expected, however, that the metal – oxygen stretching frequencies of these compounds are chemically most interesting since they are closely related to the stabilities of the chelates. Unfortunately, they are difficult to identify because they appear outside the sodium chloride region, and, furthermore, strong coupling with other modes may be involved.

We measured the spectra of thirty-two compounds of the following type in the 1,700 ~ 280 cm.$^{-1}$ region using optical components of sodium chloride, potassium bromide and cæsium bromide:



where, R_1, R_2 and M are variables. It was found that, in acetylacetonates and benzoylacetonates, the bands, ranging from 420 to 480 cm.$^{-1}$, shift to higher frequencies and increase in intensity as the metal is changed in the order (of stability): $Co^{2+} < Ni^{2+} < Cu^{2+} < Pd^{2+}$, as is shown in Table 1.

Table 1

	Acetylacetonates	Benzoylacetonates
Co^{2+}	420 cm.$^{-1}$	423 cm.$^{-1}$
Ni^{2+}	453	452
Cu^{2+}	455	458
Pd^{2+}	465	478
Al^{3+}	490	470

Also, in Cu^{2+} or Ni^{2+} chelates of various β-diketones, the same band shifts to higher frequency as R_1 and R_2 are changed in the order (of stability): CF_3, CF_3 < CF_3, CH_3 < CH_3, CH_3 < C_6H_5, CH_3 < C_6H_5, C_6H_5, as is shown in Table 2.

Table 2

R_1, R_2	Cu^{2+}	Ni^{2+}
CF_3, CF_3	——	——
CF_3, CH_3	445	427
CH_3, CH_3	455	453
C_6H_5, CH_3	458	453
C_6H_5, C_6H_5	463	460

These results seem to suggest that this band may be due to one of the metal – oxygen stretching modes or is at least closely related to it. In order to confirm this and to determine the coupling nature of this band, the normal co-ordinate treatment is necessary and will be carried out.

We wish to thank Prof. R. C. Lord, jun., of the Massachusetts Institute of Technology, for aid in obtaining the spectra in the cæsium – bromine region.

KAZUO NAKAMOTO
PAUL J. MCCARTHY
ARTHUR E. MARTELL

Department of Chemistry,
Clark University,
Worcester, Mass.
Nov. 5.

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Existence of Two Liquid Phases in the System Cobalt Chloride–Water–Acetone

Katzin and Ferraro[1] have examined the composition of the solid phases and their equilibrium solutions in the system cobalt chloride–water–acetone at 25° C. During further studies of solutions containing these components it has been noticed that for certain water–acetone mixtures the addition of cobalt chloride can lead to a separation of two liquid phases.

Fig. 1 gives the relation of the region of immiscibility to the phase diagram given in ref. 1. The results were obtained by titrating aqueous cobalt chloride solutions, made from the recrystallized 'Analar' hexahydrate, with 'Analar' acetone, weighing both the portion of aqueous solution and the final mixture with acetone. A few points were obtained by preparing saturated solutions of the salt in known water–acetone mixtures, and titrating these with acetone or with water–acetone mixtures. The points in the present work were obtained at room temperatures of 20–21° C., whereas the saturation curve was determined at 25° C. A tie-line running through the centre of the immiscible region is also included in the phase diagram. It was obtained by analysing the two phases for cobalt and for water (by a Karl Fisher titration).

The immiscible area follows the saturation curve fairly closely, but a number of experiments have shown that at 25° C. there is a single liquid phase

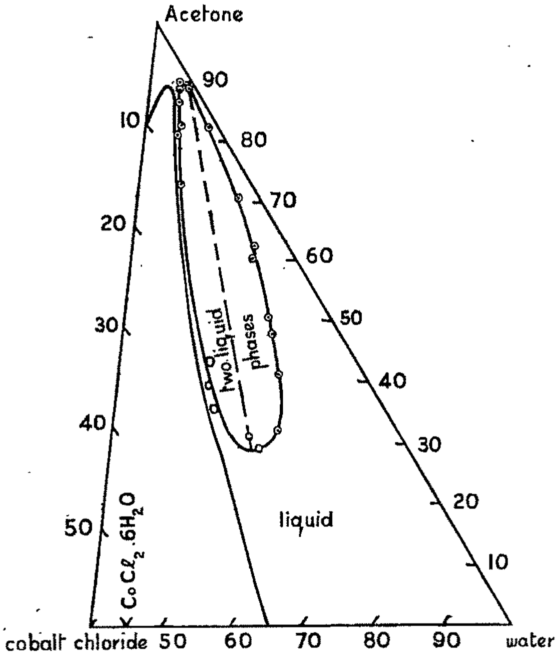

Fig. 1

at saturation. However, cooling to 20° C. may give two liquid phases in equilibrium with solid phase for solvent mixtures containing about 55 weight-per cent water, 45 per cent acetone. Single-liquid phases exclusively occur with compositions containing more than 90 per cent or less than 28 per cent acetone, and for mixtures containing less than 1 per cent of cobaltous chloride. It is interesting, as a phenomenon, that the addition of increasing amounts of cobalt chloride to a portion of, say, 50–50 water and acetone gives simple solution for a considerable concentration range; then there occurs a limited composition region in which there are two liquid phases, finally again a single liquid which remains so to saturation with solid. If the initial solvent mixture contains about 33 per cent acetone, the region of separation might appear as a minute region of turbidity only.

From the effect of temperature on some mixtures of fixed composition in sealed tubes it has been observed that the immiscible region expands as the temperature is raised. This expansion is most noticeable in the region of highest water concentrations, so that on raising the temperature we need progressively less acetone to produce a phase separation from a given cobalt chloride–water solution. The upper part of the immiscible region does not appear to be very sensitive to temperature changes.

For an over-all composition corresponding to a point near the middle of the region of phase separation, the phase rich in acetone is a light blue ($\lambda_{max.} \sim$ 672 mμ) and the phase rich in water is a deep magenta with two main regions of absorption ($\lambda_{max.} \sim$ 515 mμ, 664 mμ). These spectra correspond respectively to those for tetrahedrally co-ordinated $CoCl_2.2X$ (where X is a solvent molecule, in this case either water or acetone), and a mixture of this form with the octahedral species $Co(H_2O)_6^{2+}$, $CoCl_2.4X$, and intermediate stages.

It may be inferred that the presence of the two co-ordination states of the cobalt salt, with co-ordination four and six respectively, furnishes a mechanism for formation of two phases of different composition but with activities of the components equal. That is, the separation depends on the apparent fact that the tetrahedral form is preferentially soluble in the phase rich in acetone. The dependence of the phase separation on temperature can be understood since the equilibrium between octahedrally and tetrahedrally co-ordinated cobalt is known to move towards the tetrahedral form on raising the temperature. Other systems in which phases rich in acetone and in water are separated occur, for example, with salts such as potassium chloride and potassium fluoride, which are very soluble in the water and essentially completely insoluble in the acetone[3].

J. N. Murrell

Department of Theoretical Chemistry,
University Chemical Laboratory,
Lensfield Road, Cambridge.

L. I. Katzin*
B. L. Davies

Chemistry Division,
Atomic Energy Research Establishment,
Harwell. Jan. 5.

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* Exchange Fellow from Argonne National Laboratory, Lemont, Illinois.

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Rapid Quantitative Horizontal Paper Chromatography at an Elevated Temperature: Determination of Aspartic and Glutamic Acids

By the use of rectangular strips of filter paper, rather than filter paper disks, in combination with a horizontal solvent flow at an elevated temperature, amino-acids are rapidly separated as round compact spots rather than circular bands[1]. This is desirable since such spots in many cases lend themselves to quantitative study by the maximum colour-density technique. Recently, such a procedure has been applied to the analysis of tryptophan in an alkaline hydrolysate of α-casein[2].

This communication presents additional evidence to show that horizontal paper chromatography at an elevated temperature can be made quantitative by the maximum colour-density technique. A method is presented for the determination of aspartic and glutamic acids by direct photometry on paper chromatograms following two one-hour solvent developments at 60° C. in phenol saturated with *p*H 12·0 buffer[1].

For the glutamic acid assay, four standard amino-acid solutions (*p*H 6·5) containing, respectively, 0·100, 0·075, 0·050, and 0·025 μgm. of amino nitrogen are applied alternately to the paper in 0·5 μl. volumes at K_1, K_2, K_3, and K_4 (Fig. 1). The unknown solution is spotted at three concentrations (in 0·5-μl. volumes) to fall within the range 0·025–0·100 μgm. of the standard solutions. The aspartic acid analysis requires four standards in the range 0·075–0·150 μgm.

After colour development of the chromatogram[1], the maximum densities of the amino-acid spots are measured with a Denischron transmission densitometer (Model 3835*B*, W. M. Welch Scientific Company, Chicago, Ill.) using an aperture 1-mm. in diameter and the green filter built into the instrument. A standard curve is prepared by plotting the logarithm of the known concentrations against the densities.

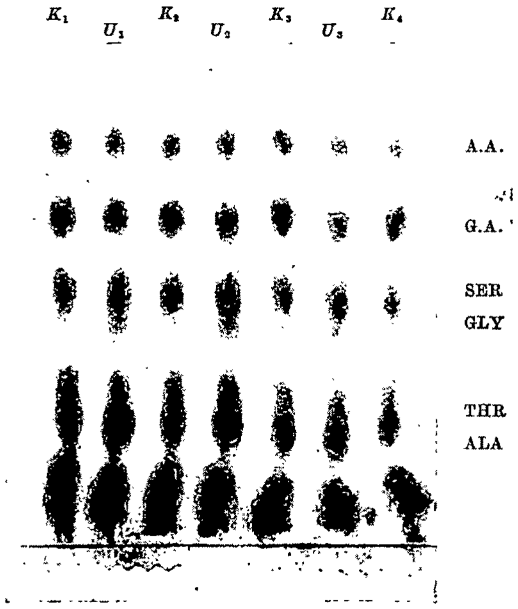

Fig. 1. A quantitative horizontal paper chromatogram of aspartic and glutamic acids after two 1-hr. solvent developments at 60° C. in phenol saturated with *p*H 12·0 buffer

Three 125-mgm. samples of an α-casein preparation[2] were hydrolysed for 24 hr. under reflux in 25 ml. solutions of 6 *N* hydrochloric acid. Following clarification of the hydrolysates as described previously[3], the dried residues were dissolved in 10 per cent *iso*propanol, filtered, adjusted to *p*H 6·5, and made up to a final volume of 25 ml. with 10 per cent *iso*propanol.

The determination of the content of aspartic and glutamic acids in α-casein gave values of 7·84 mgm. per 100 mgm. protein for aspartic acid and 20·43 mgm. for glutamic acid (Table 1). These values were in good agreement with 7·70 mgm. for aspartic acid and 21·02 mgm. for glutamic acid obtained using descending paper chromatography[4].

The accuracy and precision of the method was established by determining the aspartic and glutamic acid contents of a solution containing 40 mgm. of each of 18 common amino-acids per 100 ml. total volume, *p*H 6·5. A value of 39·0 mgm. (2·5 per cent deviation from the true value) was obtained for aspartic acid (Table 2) and 39·6 mgm. (1·0 per cent deviation) for glutamic acid. These values compared well with the values of 40·5 mgm. and 40·7 mgm. obtained for aspartic and glutamic acids using descending paper chromatography[5].

Table 1. THE ASPARTIC AND GLUTAMIC ACID CONTENT OF α-CASEIN AS DETERMINED BY HORIZONTAL PAPER CHROMATOGRAPHY

Chromatogram	Concentration found (mgm./100 mgm. α-casein) Aspartic acid	Glutamic acid
1	7·83	19·99
2	7·64	20·65
3	8·04	20·65
Average	7·84	20·43
Standard deviation	0·20	0·38
Descending paper chromatography (ref. 4)	7·70	21·02

Table 2. ACCURACY AND PRECISION OF THE HORIZONTAL PAPER CHROMATOGRAPHIC DETERMINATION OF ASPARTIC AND GLUTAMIC ACIDS

Chromatogram	Concentration found (mgm./100 ml.)	
	Aspartic acid	Glutamic acid
1	39·9	39·9
2	38·0	41·0
3	39·0	37·8
Average	39·0	39·6
Standard deviation	0·95	1·63
Deviation from theoretical value, 40 mgm./100 ml., per cent	2·5	1·0

HENRY R. ROBERTS
MICHAEL G. KOLOR

Research and Development Division,
National Dairy Products Corporation,
Oakdale, Long Island, N.Y.
Oct. 14.

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A New Sensitive Indicator for Semi-Micro Chelometric Titrations

RECENTLY, a new colorimetric reagent was introduced for the spectrophotometric determination of magnesium[1]. This reagent (LaMotte Chemical Products Co., Chestertown, Md.), 1-azo-2-hydroxy-3-(2.4-dimethylcarboxanilido)-naphthalene-1′-(2-hydroxybenzene), given the trivial name 'magon', has now been found to be useful as an indicator in the direct titrimetric determination of small amounts of magnesium.

There are several direct photometric methods for the determination of magnesium, of which titan yellow[2] and eriochrome black *T*[3] are examples. There is need for a direct titrimetric procedure for magnesium. Chelometric titrations employing ethylenediamine tetraacetate are widespread. These methods, as utilized for the determination of calcium and magnesium, include a titration of calcium and magnesium using eriochrome black *T* and a titration of calcium alone using murexide[4], zinchrome *R*[5], calcon[6] or other indicators. By the ethylenediamine tetraacetate method, magnesium is determined by difference between the two titrations. Errors encountered in either or both titrations affect the validity of the magnesium value. A direct value would be an improvement for the accurate titrimetric determination of small amounts of magnesium in the presence of large amounts of calcium.

This communication presents results of direct titrations of magnesium using the new, sensitive indicator magon. The indicator forms a coloured complex with small amounts of magnesium but not with small amounts of calcium. Magnesium in the complex is removed by titrating with ethylenediamine tetraacetate, resulting in a sharp colour-change of yellow-red to blue-violet to blue. The blue end-point is slower than the blue-violet but either colour-change can be used.

The results (Table 1) demonstrate that this indicator can be used in determining μgm. amounts of magnesium, recovery values being satisfactory. Metals such as copper and iron interfere by affecting the sharpness of the end-point. This difficulty may be alleviated by adding a small amount of solid potassium cyanide to the solution before adding the magon. The addition of a small amount of cyanide to the

Table 1. Direct Titrimetric Determination of Magnesium in Synthetic Solutions

Mgm. present γ	Ion added γ	Mgm. found* γ	Difference γ
5	—	5	0
5	—	6	1
10	—	10	0
10	—	9	1
25	—	23	2
25	—	23	2
50	—	49	1
50	—	50	0
100	—	99	1
100	—	100	0
50	Cu-25	56†	6
50	Cu-25	50‡	0
50	Cu-50	50‡	0
50	Cu-50	50‡	0
100	Fe-50	100‡	0
100	Fe-100	98‡	2
100	Fe-100	98§	2

* Procedure includes 10 ml. Clark and Lub's buffer *p*H 9·0, plus 15 ml. absolute methanol, plus 10 ml. magon (0·10 mgm./ml. MeOH). The solution is adjusted, if necessary, to *p*H 10·5 and then titrated with 0·005 *N* ethylenediamine tetraacetate.

† End-point fades, no cyanide present.

‡ 1–3 mgm. potassium cyanide added prior to addition of magon.

§ 1–3 mgm. ascorbic acid added prior to potassium cyanide.

solution should be made since large amounts slightly decrease the sensitivity of the colour-change. A buffer system, ammonium hydroxide–ammonium chloride, was unsatisfactory because of decreased sensitivity of the end point. Borate and tetraborate appear to increase a sharp colour change. Magon, essentially insoluble in water, is soluble in ethanol and methanol. Therefore the compound is dissolved in methanol and more methanol is added to the solution to be titrated. The concentration of alcohol in the solution to be titrated should range between 30 and 80 per cent. The indicator should be made fresh daily. Methanol is preferred since some decreased end-point sensitivity is encountered when using 95 per cent ethanol.

For this titration a *p*H-range of 9·0–11·0 is necessary. Clearest colour-changes are from *p*H 10·0 to 10·5. In the standardization of ethylenediamine tetraacetate with magnesium, the *p*H should be adjusted accurately to a selected *p*H within 10·0–10·5 and this same *p*H maintained for all titrations with the standardized titrant.

Under the above conditions the titration can be used for determining the combined amounts of calcium and magnesium, since calcium is titrated before magnesium. Calcium may be separated from magnesium as the precipitated calcium tungstate[7]. Preliminary results in this laboratory show magon to be very sensitive for the determination of total hardness of waters.

The possible usefulness of this new, sensitive indicator, or its magnesium complex, in the titration of micro-amounts of other metals should not be overlooked[8].

I wish to acknowledge the technical assistance of Neil Scott McNutt.

Robert H. Maier
Department of Agricultural Chemistry and Soils,
University of Arizona,
Tucson.
Dec. 23.

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Validity of Clapeyron's Equation for Phase Equilibria involving Clathrates

Clathrates are solid solutions of a volatile solute in a host lattice[1]. The quinol clathrates studied by Powell[2] and the so-called gas hydrates[3] belong to this class of substances. Their host lattices, when empty, are thermodynamically unstable. In this respect they are different from the zeolites (Barrer[4]) in which the occluded component is sorbed in a stable host lattice. This has as a consequence that univariant phase equilibria involving a clathrate, in general, have no counterpart in the case of sorption in zeolites.

Consider, for example, a binary system water plus gas in which a clathrate (hydrate) occurs. The three-phase equilibria:

$$\text{ice} - \text{clathrate} - \text{gas} \qquad (1)$$

and

$$\text{aqueous solution} - \text{clathrate} - \text{gas} \qquad (2)$$

then are univariant ones in which the composition of the clathrate varies along the three-phase lines. The heat ΔH of decomposition of the clathrate into ice and gas (1), or into solution and gas (2), can be found from the slope of the three-phase line and the change in volume ΔV, according to Clapeyron's equation:

$$\frac{dP}{dT} = \frac{\Delta H}{T\Delta V} \qquad (3)$$

The values of ΔH per mole of solute thus obtained by earlier investigators and quoted by von Stackelberg[3] and Barrer and Stuart[5] are not invalidated by the fact that hydrates are solid solutions instead of stoicheiometric compounds. Equation (3) is a direct consequence of the second law of thermodynamics, and as such exact for all univariant equilibria, irrespective of the number of components.

Quite separate from Clapeyron's equation, one has a relation which determines the change in composition of the clathrate solution necessary to maintain equilibrium with ice in (1), or with an aqueous liquid in (2), when temperature or pressure are varied (compare, for example, equation (3.12) of ref. 1*a* and equation (15) of ref. 5). The latter relation is completely analogous to the well-known formula for the depression of the freezing point of ideal liquid solutions.

Clearly, equilibrium (1) is not analogous to the sorption equilibrium of a gas in a zeolite. The latter is a bivariant equilibrium to which Clapeyron's equation is not applicable, and for which the heat of desorption is proportional to the derivative $(\partial P/\partial T)$ at constant sorbed excess number of moles (cf. ref. 6, pp. 201–205, for an elegant treatment of this problem).

J. H. van der Waals
J. C. Platteeuw
(N.V. De Bataafsche Petroleum Maatschappij),
Koninklijke/Shell-Laboratorium,
Amsterdam.

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THERE is a difficulty which can occur regarding the interpretation of heats derived from Clapeyron's equation applied to phase equilibria involving clathrates. This difficulty is not thermodynamic in origin but arises from the non-stoicheiometry of the phases. Before this non-stoicheiometry was realized, heats evaluated using Clapeyron's equation were considered to refer to fully stoicheiometric reactions, for example:

$$CHCl_3 + 17H_2O \rightarrow CHCl_3.17H_2O \qquad (1)$$

the values 1 and 17 here being regarded as fixed integers. However, equation 1 should be formulated as:

$$xCHCl_3 + 17H_2O \rightarrow xCHCl_3.17H_2O \qquad (2)$$

where x is less than 1, has not a fixed value but may vary with P and T, was unknown to earlier experimenters and indeed in this and many analogous systems is still unknown. x could vary from one experimenter to another according to the physical conditions employed. The heats derived have therefore referred to uncompleted reaction equations and so have an uncertain meaning[1], until x is determined at the same time as the heat of reaction. Fortunately, x in many cases does not differ greatly from an integer, so that uncertainties resulting from non-stoicheiometry are not large.

R. M. BARRER

Physical Chemistry Laboratories,
Imperial College,
London, S.W.7.

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BIOCHEMISTRY, PHYSIOLOGY and MEDICAL SCIENCES

Glucuronide and Sulphate Conjugation *in vivo* and *in vitro*

EARLY studies[1] of the metabolism of the polycyclic hydrocarbon 3:4 benzypyrene showed that this compound was converted within mouse and rat tissues to one or other of two water-soluble derivatives. These were characterized physically, but not chemically identified, and for convenience in later work were labelled as BpX_1 and BpX_2.

Later, Calcutt and Payne[2] showed that within mouse or rat liver—the major site of benzpyrene metabolism—BpX_1 was formed only in association with the heavy components of the soluble proteins representing the supernatant fraction of cell homogenates. On the other hand, BpX_2 was formed in the nuclei, mitochondria, microsomes and lighter components of the supernatant. The major site of formation of this derivative was the microsomes[3].

Harper[4] has now obtained evidence that BpX_1 is a mixture of the sulphuric acid conjugates of fully aromatic benzpyrenols, while BpX_2 is a mixture of the glucuronic acid conjugates of the same phenols.

It now becomes possible to correlate the above results concerning the primary metabolism of benzpyrene with other information in the literature dealing with *in vitro* systems of conjugation. It has been shown by Bernstein and McGilvery[5] and De Meio *et al.*[6] that sulphate conjugation *in vitro* is based upon an enzyme system present in the high-speed fraction of the supernatant from liver homogenate. Activity is dependent upon the presence of adenosine triphosphate and magnesium ions. The identification of the benzpyrene X_1 derivative as a mixture of sulphuric acid esters now gives an example of correspondence between *in vivo* and *in vitro* conjugation systems. In both cases sulphate conjugation has been found to be associated with the same cellular sub-fraction.

In the case of glucuronide synthesis *in vitro* activity has been found in the microsome fraction of liver homogenate[7,8] and to a lesser extent in nuclei and mitochondria[9]. With the recent proof that benzpyrene X_2 is a mixture of glucuronic acid conjugates we again have an exact parallel between *in vivo* and *in vitro* behaviour. In this case the parallel is not only with regard to the cellular sub-fractions concerned but also with the relative amounts of conjugate formed.

So far as we are aware this evidence, based on work with 3:4 benzpyrene, is the first example of known *in vitro* systems for glucuronic and sulphuric acid conjugation proving to be an accurate reflexion of behaviour in whole tissues under *in vivo* conditions. Furthermore, it is also apparent that the processes of homogenization and ultracentrifugation involved in the extraction of these enzyme systems for *in vitro* use do not result in the loss or redistribution of these systems.

K. H. HARPER
G. CALCUTT

Department of Cancer Research,
Mount Vernon Hospital.
Northwood, Middlesex. Nov. 26.

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Conjugated Forms of Urobilinoid Pigments

TAKASHI NORO[1] reported a fraction of urinary urobilinoids not extractable with chloroform but extractable by saponification with potash; this fraction he assumed to be in the ester form of the urobilinoids. We have found that some of the urinary urobilinoids not extractable with chloroform are characterized by their adherence to the gel-like precipitate formed during the extraction. Shaking normal urines, or preferably those from cases of hæmolytic jaundice, with Sevag's chloroform–amyl alcohol (9:1) mixture[2] results in partition of their urobilinoid contents. After centrifugation, part of the urobilinoids are found bound to the precipitate which collects at the interface and are extractable from it with ethyl acetate but not with chloroform, while the other part passes into the chloroform – amyl alcohol phase.

The paper chromatographic behaviour of these fractions was different. (Solvent: chloroform saturated with water–butanol–pyridine saturated with water (2·2 : 1·8 : 1); the urobilinoids were visualized by their green fluorescence in ultra-violet light after spraying with Schlesinger reagent.) The fraction extracted with chloroform migrated with the solvent front, but the bound urobilinoids behaved as a mixture of at least two compounds, the first of these remained at the start line, while the second moved slowly as an oblong spot behind the front. The first spot was readily stainable with protein dyes (for example, acid fuchsin) and by mucopolysaccharide staining procedures[3-5], thus showing its mucoprotein-bound character; the second spot was faintly stained by the latter procedure, and coloured brown by aniline hydrogen phthalate reagent[6] after heating, but was unstained by protein dyes, in accordance with the assumption that it is an oligo- (or mono-) saccharide-conjugated compound. The spot migrating with the front remained unstained by either procedure, which proved that it was free urobilinoid.

The mucoprotein-bound urobilinoids may be prepared separately from the oligo- (mono-) saccharide-conjugated urobilinoids by centrifugation of (*a*) the gel-like precipitate formed by extracting urines with ethyl acetate, or (*b*) of urines saturated with ammonium sulphate after adding 1·5 per cent butanol. This latter method (suggested by Heikel[7] for the preparation of directly reacting bilirubin from urine) yielded bound urobilinoid most abundantly. The mucoprotein-bound moiety can be lifted as a reddish-brown pellicle from the top of the aqueous phase; the oligo- (mono-) saccharide-conjugated urobilinoids pass into the ethyl acetate or butanol supernatant, respectively. The mucoprotein-bound urobilinoids seemed to behave, however, as a source of the oligo- (mono-) saccharide-conjugated pigments, which split off after incubation for 1 hr. at 37° C.; this decomposition was inhibited by 250 μgm./ml. heparin, but enhanced by 2 mgm./ml. trypsin. This splitting from mucoproteins occurred also during paper electrophoresis in Michaelis barbital buffer solution, *p*H 8·6, the oligo- (mono-) saccharide-linked urobilinoids leaving the mucoproteins and moving towards the anode-like free urobilinoids[8].

During electrophoresis in borate buffer (*p*H 8·6; 0·2 *M* H_3BO_3; 0·05 *M* $Na_2B_4O_7$), however, the oligo- (mono-) saccharide-conjugated and free urobilinoids behaved differently. Under these conditions carbohydrates have characteristic mobilities due to the formation of borate complexes, for example, glycuronic acid migrates 1·4 times as fast as dextrose[9]. Borate buffer electrophoresis of the supernatant formed after butanol has been added to urines precipitated by saturation with ammonium sulphate and centrifuged gave three urobilinoid bands, the fastest zone moving 1·4 times faster than dextrose. This zone and the middle one were coloured brown by spraying with aniline hydrogen phthalate and heating. The slowest zone behaved like free crystalline sterkobilin, and both were unstained by aniline hydrogen phthalate. The bands were cut out, extracted separately with the borate buffer described above, and the extracts were tested by Dische's carbazol reaction[10]. The fastest zone proved to contain glycuronic acid, while the slowest one did not.

Gray[11] expected work to be done on the conjugated urobilinoid pigments in urine; the above observations favour the assumption that besides free urobilinoids, urobilinoid glycuronide and another sugar-linked form, at present under investigation, may exist. Possibly these split from mucoprotein-urobilinoid compounds. These forms of urobilinoids were found to be more resistant to oxidation and decomposition during electrophoresis than free urobilinoids[12].

We are indebted to Prof. C. J. Watson for his gift of crystalline sterkobilin used in these experiments.

I. L. Kahán
Department of Medicine,

A. Kahán
Department of Ophthalmology,
University Medical School,
Szeged, Hungary. Oct. 3.

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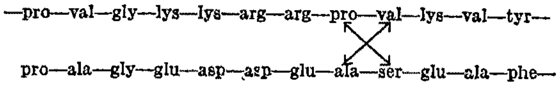
Patterns in the Amino-Acid Sequences of the Corticotropins

The complete amino-acid sequences of pig and sheep adrenocorticotropic hormone have been elucidated[1-3]. They have almost identical structures showing only minor variations in the C-terminal region. A striking similarity in pattern occurs in the acidic and basic portions of these proteins, although these regions are comprised for the most part of different amino-acids. This pattern becomes obvious when the amino-acid sequence 24–35 of the acidic portion is listed directly beneath sequence 12–23 of the basic portion. The actual sequences for amino-acids 12–35 are shown in Table 1*a* and *b* for the two proteins. Table 1*d* is a hypothetical sequence compiled from the best pattern correspondence in both. The other portions of both corticotropins, sequences 1–11 and 35–39, are identical.

Table 1. AMINO-ACID SEQUENCES OF SHEEP AND PIG ADRENOCORTICOTROPIC HORMONE

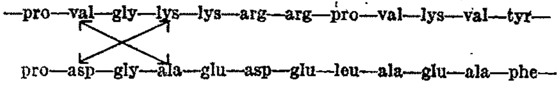
(*a*) Sheep α-corticotropin (ref. 3)



—pro—val—gly—lys—lys—arg—arg—pro—val—lys—val—tyr—

pro—ala—gly—glu—asp—asp—glu—ala—ser—glu—ala—phe—

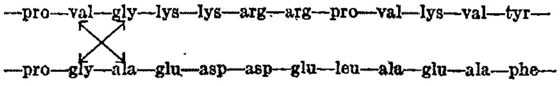
(*b*) Pig β-corticotropin (refs. 1 and 2)



—pro—val—gly—lys—lys—arg—arg—pro—val—lys—val—tyr—

pro—asp—gly—ala—glu—asp—glu—leu—ala—glu—ala—phe—

(*c*) Pig corticotropin-*A* (ref. 4)



—pro—val—gly—lys—lys—arg—arg—pro—val—lys—val—tyr—

—pro—gly—ala—glu—asp—asp—glu—leu—ala—glu—ala—phe—

(*d*) Hypothetical sequence

12	13	14	15	16	17	18	19	20	21	22	23
—pro—	val—	gly—	lys—	lys—	arg—	arg—	pro—	val—	lys—	val—	tyr—
pro—	ala—	gly—	glu—	asp—	asp—	glu—	leu— —ser—	ala—	glu—	ala—	phe—
24	25	26	27	28	29	30	31	32	33	34	35

In the hypothetical sequence proline occurs at positions 12 and 24, glycine at positions 14 and 26, and aromatic amino-acids at positions 23 and 35. There is no correspondence at positions 19 and 31. The acidic amino-acids in the bottom chain are found in positions corresponding to those occupied by the basic amino-acids in the top chain, although there is no correlation between any one of the acidic (glutamic or aspartic) with any one of the basic (lysine or arginine) amino-acids. Similarly, valine on the top chain is replaced by alanine on the bottom. Each of the corticotropins differs from this hypothetical correspondence in pattern by a switch in the positions of two amino-acids in the acidic portion. In pig β-corticotropin, alanine exchanges position with aspartic, and in sheep α-corticotropin, alanine switches with serine. White and Landmann[4] have proposed a slightly different sequence (corticotropin-*A*) for the acidic portion of pig hormone that deviates from the hypothetical sequence only in that alanine in position 25 switches with glycine in position 26 (Table 1*c*).

The repetition of the pattern in the two regions suggests a duplication of the information template that confers the specificity. On a strict gene-template hypothesis having each amino-acid independently specified by a restricted region of the template, a remarkable series of mutations is required in the duplicate region such that the overall pattern is maintained but different amino-acids are specified. I prefer a scheme postulating two levels of information[5], one designating the pattern and the other determining which amino-acids will be incorporated into the pattern. Much of the biological specificity may reside in the pattern rather than in the individual amino-acids, since it has been shown that many major changes can be made in the chemical structure of peptides without affecting their biological specificity[6].

DREW SCHWARTZ

Biology Division,
Oak Ridge National Laboratory*,
Oak Ridge, Tennessee.
Dec. 5.

* Operated by Union Carbide Corporation for the U.S. Atomic Energy Commission.

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Distinction between Sodium and Potassium in Change in Permeability effected by Lipid-soluble Analogues of Acetylcholine

B. C. Abbott, A. V. Hill and J. V. Howarth have recently found that a rather strong positive heat roughly coinciding with the active phase follows within 100–300 msec. by a marked negative heat[1]. These results make untenable the assumption of a purely physical process underlying the bioelectric currents during nerve activity as proposed by Hodgkin and his associates. Further support for the necessity of a chemical reaction are the observations of Schoffeniels[2] with the isolated single electroplax of *Electrophorus electricus*: he found a Q_{10} of 3·6 for the action potential; the activation energy is 21,000 cal./mole.

A theory postulating a chemical reaction to be responsible for the change in permeability during conduction was suggested by Nachmansohn fifteen years ago. He proposed that the action of acetylcholine is an intracellular (or intramembranous) process essential for the generation of bioelectric currents. This view is based on a variety of physiological and biochemical features of the acetylcholine system which has the prerequisites for the postulated function, and on its relationships with electrical activity[3].

One of the principal objections to Nachmansohn's theory was the failure of acetylcholine to affect conduction when applied externally. This lack of effect has been explained by the failure of acetylcholine to reach the active sites, since it has been demonstrated that the ester does not penetrate to the inside of the cell[4,5]. Recently, however, a number of lipid-soluble analogues of acetylcholine were prepared. These compounds depolarize the axon in low concentrations and produce muscular contraction by direct action on the conducting membrane. The effects are rapid and, under appropriate conditions, reversible. In still unpublished experiments on isolated nodes of Ranvier, Staempfli and Dettbarn obtained depolarization with 10^{-6} *M* concentration (equivalent to 0·2 μgm. of acetylcholine per ml.). The question naturally occurs about the specific nature of this effect. Evidence in favour of a reaction with the acetylcholine receptor was obtained in experiments with eserine in which antagonistic actions between the alkaloid and the quaternary ammonium ion were found and their competitive nature was demonstrated[6,7].

The problem arises whether the lipid-soluble quaternary ammonium ions change the permeability in a way consistent with the assumption that their action opens the barrier specifically for Na^+, as postulated for acetylcholine, or whether the compounds produce an indiscriminate increase in permeability. This question is important since during activity Na^+ conductance specifically increases several hundred-fold; increase in K^+ conductance follows later and is relatively small. This question has been tested in the following way.

Desheathed tibialis nerve fibres of *Rana pipiens* were exposed to Ringer's solution containing the following lipid-soluble quaternary ammonium ions: noracetylcholine 12 and pyridinium dodecyl iodide (in 10^{-4} *M*) and pyridine aldoxime dodecyl iodide (in 10^{-5} *M*). At these concentrations no effect on the resting potential was observed. When the K^+ concentration in these solutions was raised to 20 m*M*, the depolarization which is usually observed was significantly reduced (about 20 per cent) both in respect to strength and in respect to speed of the response. In all experiments the response to the same K^+ concentration was tested prior to the addition of the quaternary ammonium ions. The results indicate a small but definite decrease of permeability to potassium.

The change to Na^+ permeability effected by these compounds was tested with concentrations five times as high, at which there is a pronounced depolarizing effect in normal Ringer's solution. When Na^+ was replaced by choline chloride, the depolarization was strongly reduced (by 30–50 per cent). On replacing again choline by Na^+, the original strength of depolarization was restored. Thus, the depolarization appears to be effected by a marked increase of permeability to Na^+. The selective change of permeability; small although significant decrease to K^+, marked increase for Na^+, appears pertinent in connexion with the assumption that the lipid-soluble analogues of acetylcholine mimic the physiological action postulated for the ester.

This work was supported by the Division of Research Grants and Fellowships of the National Institutes of Health, U.S. Public Health Service, Grant No. *B*-400 *C5*, and by the Atomic Energy Commission, Contract No. *AT*(30-1)-1503.

Wolf D. Dettbarn

Department of Neurology,
College of Physicians and Surgeons,
Columbia University,
New York.
Jan. 9.

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Depression in Percentage of Milk Fat by Parenteral Glucose Infusion and Glycerol Feeding

Low roughage - high concentrate diets can profoundly depress the fat content of milk[1-6]. One of us has advanced the hypothesis[6] that such depressions are the result of metabolic effects of an increase in the proportion of glycogenic to non-glycogenic products of digestion on such diets. Such an increase could be effected by a proportion of the starch escaping ruminal digestion, high ruminal lactic acid production, and an increased proportion of the glycogenic propionic acid in the products of ruminal digestion. There is evidence that low roughage - high concentrate diets have such effects[5,7,8]. It is also known that the proportions of fat and carbohydrate in the diet of animals can profoundly affect their carbohydrate and lipid metabolism, and changes, although erratic, in blood lipids have been recorded on low roughage diets[5,9], indicating some disturbance of lipid metabolism.

Experiments supporting the above hypothesis are now reported. Cows on normal hay concentrate diets giving milk with normal milk fat percentage were given continuous intravenous infusions of glucose over 48 hr. at the rate of 2 kgm. per 24 hr. and the fat percentage of the milk produced before, during and after the infusion determined. Oxytocin injections were used for obtaining as complete as possible evacuation of the udder at each milking. Normal feed consumption continued during the experiments. Results of a typical experiment are recorded in Fig. 1. Rate of milk production was maintained at quite a constant level during the infusion but fat percentage was rapidly depressed. Similar results were obtained when the concentrate allowance was decreased by an amount calculated to supply the same amount of net energy as the infused glucose.

Glycerol feeding, which would result in an increased proportion of glycogenic to non-glycogenic products of digestion due to high propionic acid production[10], was also found to depress milk fat percentage (Table 1) in agreement with the hypothesis. The glycerol was added to normal hay - concentrate diets, replacing an amount of concentrates calculated to supply the same amount of net energy.

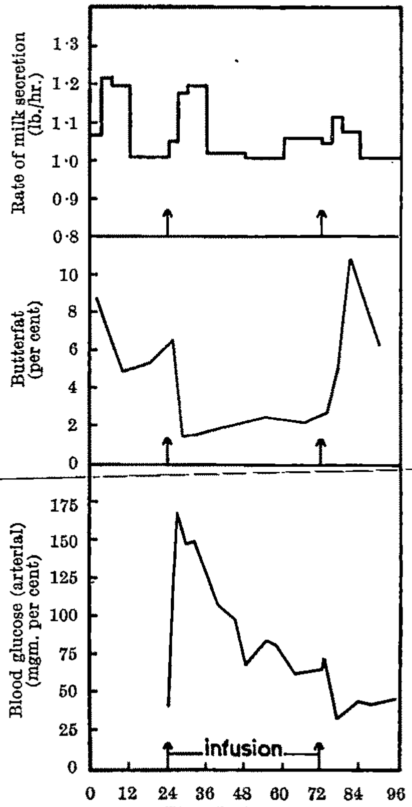

Fig. 1. Effect of intravenous infusion of glucose on the rate of secretion of milk, the butterfat test, and the level of blood glucose in a Jersey cow

It has been suggested that the fall in percentage of fat on low roughage - high concentrate diets is caused by lack of supply of acetate to the mammary gland, and acetate feeding has been reported to return depressed fat percentages to normal[3,4,11]. However, it has been shown that volatile fatty-acid levels in the blood and uptake by the mammary gland are not noticeably reduced on such diets[6]. Although it has yet to be demonstrated that the volatile acid in the blood is predominantly acetic as it is on normal diets[12], it seems likely that the positive results from acetate feeding are due to restoration of a more normal proportion of glycogenic to non-glycogenic products of digestion rather than to remedying an absolute lack of acetate.

Studies on the effect of the glucose infusions on blood lipid fractions are now in progress.

Grateful acknowledgment is made to the Commonwealth Bank of Australia for a grant from the Rural

Table 1. EFFECT OF GLYCEROL FEEDING (6 LB./COW/DAY) ON BUTTERFAT CONTENT OF MILK

	Pre-treatment period (13 days)	Glycerol feeding period		Post-treatment period (13 days)
		(days 1–3)	(days 3–13)	
Mean milk production (lb./cow/day)	26·6	26·4	24·8	22·3
Mean butterfat (per cent)				
Cow 1	4·76	4·14	3·81	4·63
Cow 2	5·32	4·87	4·55	5·85
Cow 3	4·68	4·53	3·42	4·94
Mean	4·85	4·42	3·82	5·00
Depression (per cent)		−10·16	−22·36	

Credits Development Fund for assisting with the supply of equipment for this work.

W. S. Vallance
G. L. McClymont

Department of Nutrition and
Chemical Pathology,
Faculty of Rural Science,
University of New England,
Armidale, New South Wales.

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Changes in the Secretion of 20α-Hydroxypregn-4-en-3-one by the Adrenal Gland of Young Calves

In a previous communication[1], we described the isolation of progesterone from the adrenal venous blood of cattle. During the course of this work it was observed that progesterone was sometimes accompanied by a more polar α,β-unsaturated ketosteroid in the young calf. Since changes in the nature of adrenocortical secretion have been observed during the early life of calves[2], it seemed appropriate to examine, first, the possibility of a relationship between progesterone and corticoid secretion; secondly, the relationship between the unknown steroid and progesterone; and thirdly, the chemical nature of the unknown steroid.

Adrenal venous blood was collected from 23 male and female Jersey and Guernsey calves, and the plasma was extracted in the manner previously described[1]. The results were not corrected for extraction losses, which were of the order of 40 per cent for progesterone; these losses would be slightly more for the unknown compound because of its greater polarity in the counter-current distribution system. In 10 animals the levels of cortisol and corticosterone were also determined in the adrenal venous plasma. For these estimations, the plasma, after treatment with 0·45 per cent sodium hydroxide, was extracted twice with an equal volume of ether followed by an equal volume of ethyl acetate. The dried residue from these extracts was acetylated with acetic anhydride labelled with carbon-14 in the presence of pyridine and carbon tetrachloride. The acetates so formed were separated on paper by the *B* system of Bush[3]. The areas of radioactivity corresponding to cortisol and corticosterone acetates were measured by the use of a windowless gas-flow Geiger–Müller counter coupled to a recording ratemeter. Recoveries of cortisol by this method were of the order of 70 per cent.

The unknown compound was found to have the same R_F value in a ligroin/80 per cent methanol paper chromatographic system as 20α-hydroxypregn-4-en-3-one, and the R_F values of the acetates of these two compounds were also identical. In addition, the unknown had an ultra-violet absorption maximum at 240 mμ characteristic of an α,β-unsaturated ketosteroid; after treatment with concentrated sulphuric acid[4], it gave an absorption maximum at 290 mμ, as did 20α-hydroxypregn-4-en-3-one. On oxidation with chromium trioxide[5], the unknown yielded a compound chromatographically indistinguishable from progesterone. On the basis of this information the unknown was therefore identified as 20α-hydroxypregn-4-en-3-one, and this has since been confirmed by a comparison of the infra-red spectra of the two compounds. The concentration of this steroid in the adrenal venous blood was always considerably in excess of the concentration found in peripheral blood, indicating that it was in fact secreted by the adrenal glands.

The secretion of 20α-hydroxypregn-4-en-3-one in comparatively large amounts by the adrenal gland continued under our conditions during the first 58 days of post-natal life, and between days 58–64 there was a change-over to the secretion of progesterone. This change was not associated with any alteration in the cortisol/corticosterone ratio (Table 1).

20α-Hydroxypregn-4-en-3-one has not hitherto been recognized as an adrenal steroid; however, it has been isolated from a number of other tissues in man[6], sheep[7] and rat[8], where it is generally regarded as a metabolite of progesterone. Its presence in the adrenal venous blood of calves was unexpected, since the 20β epimer is the major compound of this type present in adult cattle[9–11]. The only activity attributed to 20α-hydroxypregn-4-en-3-one so far is that of a weak progestational agent[6], and it is not yet possible to assess the significance of this 20-hydroxy compound in the adrenal secretion of the young calf.

Table 1

Age of calf (days)	No. of animals and sex	Mean 20α-Hydroxypregn-4-en-3-one conc. μgm./100 ml. plasma	Ratio $\frac{\text{20α-Hydroxypregn-4-en-3-one}}{\text{Progesterone}}$	Ratio $\frac{\text{Cortisol}}{\text{Corticosterone}}$
1	6 male	3·2	>3·9	—
	2 male	—	—	>15·4
2	1 male	4·2	>2·1	12·5
23	1 male	22·3	20·3	1·4
32	1 male	12·0	>6·0	2·2
40	1 female	19·2	12·8	2·2
43	1 male	3·6	1·7	—
45	1 male	16·0	5·5	—
50	1 male	1·4	>1·4	—
56	1 male	8·3	1·0	—
58	2 male, 1 female	6·0	0·7	—
	1 male, 1 female	—	—	2·7
64	3 male	<1·9	< 0·13	—
	1 male	—	—	3·6
69	1 male	<1·0	< 0·04	—
80	1 female	<2·0	< 0·2	—
334	1 male	< 1·0	< 0·2	3·9

We wish to thank the Medical Research Council Steroid Reference Collection (Dr. W. Klyne) and Dr. W. G. Wiest for supplies of 20α-hydroxypregn-4-en-3-one,. and Dr. N. Sheppard for carrying out the infra-red analysis.

W. E. BALFOUR
R. S. COMLINE

Physiological Laboratory,
University of Cambridge.

R. V. SHORT

Agricultural Research Council
Unit of Reproductive Physiology
and Biochemistry,
Department of Veterinary Clinical Studies,
University of Cambridge. Nov. 28.

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Penicillin as an Antigen

THE ability of penicillin to function as an antigen, or more probably as a haptene, has only recently been described. Using the penicillin-sensitized red cell technique of Ley *et al.*[1], we have encountered eighteen sera from approximately 1,200 specimens, obtained from hospitalized patients, which have caused hæmagglutination. Preliminary testing was carried out on white porcelain tiles at room temperature using a 5·0 per cent suspension of group O, Rh-negative sensitized cells. Positive sera were titrated in 3 in. × ½ in. tubes at 37·0° C. and at 4·0° C. Control non-sensitized cells were included.

Subsequent investigation of the nature of the antibody involved in the reaction was mainly carried out on one serum which was arbitrarily scored as ++++ hæmagglutination by the tile method. Some characteristics of this serum are shown in Table 1.

Table 1

Hæmagglutinin titre (inactivated serum)	1/250
Hæmolysin titre (37·0° C. with complement)	1/64
Complement-fixation test (antigen–penicillin solution)	Positive fixation of complement
Heat stability of antibody	Withstands 56·0° C. for at least 6 hr.
*p*H range of hæmagglutination reaction	Active over range approximately 4·6–9·0

This patient had been receiving one mega unit of penicillin every 6 hr. for 4 weeks, and 7 days after cessation of therapy the hæmagglutinin titre rose to 1/1,000.

When a saline suspension of crystalline penicillin *G* was added in varying concentrations to varying dilutions of serum, an exponential-type curve was obtained when the reciprocals of the serum dilutions were plotted against the lowest concentrations of penicillin required to just inhibit hæmagglutination. The fact that proportionally higher concentrations of penicillin were needed to prevent hæmagglutination at the lower serum dilutions suggests that the antibody inhibition of penicillin is similar, in some respects, to that exerted by penicillinase.

The addition of penicillinase to penicillin-sensitized cells resulted in a considerable delay in the time required for hæmagglutination, but did not affect the final titres. This effect is apparently not due to destruction of penicillin adsorbed on to the cell surface since repeated washing of penicillinase-treated sensitized cells with 0·85 per cent saline restores fully the rate of subsequent agglutination by the serum.

Precipitin reactions both in tubes and by double diffusion techniques in agar gels have so far yielded negative results.

Our findings regarding the nature of this phenomenon differ in some respects from those described by Ley *et al.*[1]. These workers reported that certain sera gave positive hæmagglutination with the anti-globulin test. Repeated attempts with varying batches of anti-globulin sera have failed to substantiate this finding. In addition, direct Coombs's tests performed on the patient's own cells have also been negative, although the addition of penicillin solution to patient's washed cells results in agglutination indicating that antibody is apparently adsorbed on to the cell surface. These findings, however, appear to be explained by the results obtained from starch gel electrophoresis of the sera.

Attempts to characterize the antibody by conventional paper electrophoresis failed because it proved impossible to elute the antibody with saline from the paper. Ley *et al.*[1] were apparently able to elute antibody from sensitized cells by heating in saline at 54·0° C. for 15 min.; but we have been unable to confirm this observation. Starch gel electrophoresis according to the method of Smithies[2], however, proved a satisfactory procedure. After slicing the gels, one-half was stained with amido-black 10*B* for 30 sec. and cleared for approximately 10 min. in a mixture of methanol – distilled water – acetic acid (25 : 75 : 10 v/v). The high concentration of water prevented shrinkage of the gel for this period of time. The sliced portions of gel were matched, and fractions corresponding to the visualized separations in the stained half were cut from the unstained section. Each fraction was snap-frozen in dry ice and ether and then eluted with saline. The presence of antibody in each fraction was tested by the tube method. The starch remaining in the slots was examined by the same procedure. Antibody activity was consistently demonstrable in what Smithies[2] originally named pre-albumen$_1$ and pre-albumen$_2$. Pre-albumen$_2$ has now been identified as being acidic α_1-glyco-protein by Poulik and Smithies[3]. Pre-albumen$_1$ remains unidentified. In one patient difficulty was experienced in making all the antibody enter the gel and some activity remained in the slots. This patient, however, had a grossly abnormal protein pattern as a result of cirrhosis and secondary carcinomatous deposits in the liver. To be quite sure that antibody activity was associated with both fractions and not the result of trailing or irregular migration artefacts, the pre-albumen zone was differentiated by serial section and the titre of each fraction obtained was established. By this means two peaks of activity were demonstrated corresponding to the two pre-albumen zones. Control normal sera gave consistently negative results. It is stressed that the antibody has mobilities corresponding to the two pre-albumen zones, and may or may not be identical with these two fractions.

Further investigation of these sera is in progress, and it has been found that penicillin-sensitized bentonite particles can be substituted for red cells with satisfactory results.

K. C. Watson
S. M. Joubert
M. A. E. Bennett

Department of Pathology,
University of Natal,
Durban.

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Metabolism of Sulphobromophthalein

Despite the great sensitivity and widespread use of sulphobromophthalein (BSP) retention as an index of liver function, little is known of the actual function(s) involved in the hepatic uptake and excretion of the dye. Presumably, sulphobromophthalein is bound to proteins in the serum and is thus conveyed to the liver, where the pigment–protein complex is broken. On release it is excreted into the bile as the free dye[1]. We have found, however, that pigments of sulphobromophthalein appearing in the bile and other biological fluids are chromatographically different from the parent compound[2], suggesting that a chemical modification is involved in the clearance of sulphobromophthalein by the liver.

Sulphobromophthalein in human bile, urine or serum was extracted with 3 vol. of acetone. The extract was taken to dryness and subjected to paper chromatography in an ascending system, employing *t*-butanol/water (30 : 17·3 v/v). In bile, three pigments, arbitrarily designated as BSP–*A*, –*B* and –*C*, were distinguishable from free sulphobromophthalein (Fig. 1). Since incubation of sulphobromophthalein with bile at 37° C. for 24 hr. gave rise only to free sulphobromophthalein, these products were not the result of an extrahepatic complex formation in the bile.

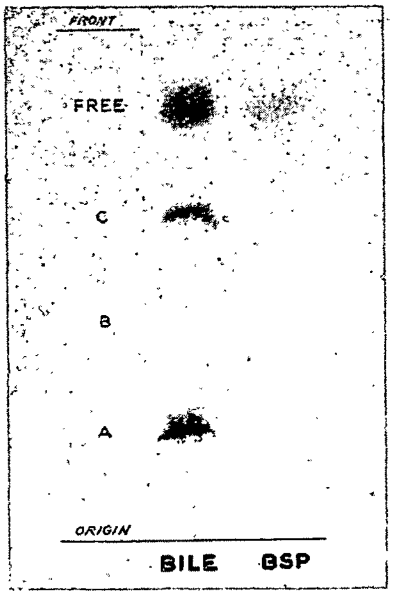

Fig. 1. Paper chromatogram of sulphobromophthalein pigments appearing in human bile

Based on their absorption at 575 mμ, the metabolites represented 65–75 per cent of the total sulphobromophthalein pigments appearing in human bile and urine, BSP–*A* usually being the most abundant. Only trace amounts of BSP–*A* and –*C* were obtained from serum. The metabolites have been similarly demonstrated in bile and urine from the rat, rabbit and dog.

Most of the proteins were removed during the acetone extraction, and the small amounts remaining were held at the origin during the chromatographic procedure. It is concluded, therefore, that the chemical differentiation between sulphobromophthalein and its metabolites is not dependent on protein.

To indicate that the production of sulphobromophthalein is a function of liver tissue, this substance was perfused through isolated liver from the rat. (We wish to thank Dr. G. L. Plaa and Dr. C. H. Hine for performing the perfusion phase of these experiments.) 90 per cent of the biliary sulphobromophthalein appeared as BSP–*A* and –*C*.

For further purification, sulphobromophthalein was extracted from bile or urine with acetone as above, dried and subjected to paper electrophoresis (Whatman 3 *MM* paper; 0·25 *M* acetic acid; 10 m.amp.; 1·5 hr.). The pigments (which move toward the anode) were eluted with water and the fractions of sulphobromophthalein were separated by chromatography in the *t*-butanol/water system. Each of the fractions was eluted with water and further purified by paper chromatography in an ascending system, using 5·2 parts *n*-butanol, 3·5 parts water and sufficient acetic acid to form a single-phase solution. Although these treatments nominally would be expected to result in a pure preparation, infra-red spectrographic observations indicated that significant impurities were still present.

The pigment characteristics of the purified BSP–*A* and –*C* were indistinguishable from those of the parent sulphobromophthalein; all three had identical absorption spectra in the visible range (single peak at 575 mμ) and identical curves when the absorption at 575 mμ was plotted against *p*H (indicator range was approximately 7·8–10·0).

The possibility that the metabolites are conjugates of sulphobromophthalein was investigated. BSP–*A* does not appear to be a glucuronide, since it is stable to hydrolysis with hydrochloric acid (0·2 *N*; 100° C.; 1 hr.), sodium hydroxide (0·2 *N*; 100° C.; 1 hr.) or with *B*-glucuronidase (*p*H 5·2; 37° C.; 25 hr.), and was negative for the presence of hexuronic acid when tested by the Dische reaction[3]. No hydroxamic acid was produced when the metabolite of sulphobromophthalein was treated with hydroxylamine reagent[4], suggesting the absence of an ester linkage in the molecule. Since ethereal sulphates are usually labile in hot dilute acid[5], it is unlikely that BSP–*A* is this type of conjugate.

Association of ninhydrin-positive material with the BSP–*A* fraction was consistently observed. A comparable chromatographic fraction from control bile or urine which contained no sulphobromophthalein was ninhydrin-negative. Rigorous hydrolysis with hydrochloric acid (6 *N*; 120° C.; 18 hr.) effected complete breakdown of BSP–*A*, yielding sulphobromophthalein, its decomposition products (moving with the front on paper), and a new substance(s) which was ninhydrin-positive and did not contain sulphobromophthalein. Final identification of the ninhydrin-positive compound(s) has been complicated by the appearance, after similar hydrolytic treatment, of ninhydrin-positive impurities in the comparable chromatographic fraction of the control bile or urine. Further purification to facilitate identification of these metabolites is being carried out.

Some of these results were presented before the Pacific Coast Section of the Society for Experimental Biology and Medicine, San Francisco, on February 20, 1957.

While this manuscript was in preparation, Krebs and Brauer[8], utilizing alumina columns, were also able to isolate unidentified metabolites of sulphobromophthalein from bile.

G. M. Grodsky
J. V. Carbone
R. Fanska

Department of Medicine,
University of California School of Medicine;
and the Gastrointestinal Clinic
(University of California Service),
San Francisco Hospital,
San Francisco.
Nov. 13.

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Anti-Thyroid Action of β-Aminoethyl*iso*thiouronium Dibromide in Rats

During the development of a screening test for goitrogenic activity of drugs, β-aminoethyl*iso*thiouronium dibromide, a radiation protective agent[1], was observed to have anti-thyroid activity. In view of possible long-term administration of this substance for prophylactic protection against irradiation, we are reporting our findings.

β-Aminoethyl*iso*thiouronium dibromide was prepared from ethylene imine and thiourea. 13·5 ml. ethylene imine (Chemirad Corp., Port Washington, New York) was dissolved in 80 ml. ether and the sediment removed. To this solution, chilled in a salt-ice bath, was added slowly a solution of 19·0 gm. thiourea and 57·8 ml. 48 per cent hydrobromic acid (s.g. 1·49) in 80 ml. methanol. After 6 hr., the precipitate of β-aminoethyl*iso*thiouronium dibromide which formed was removed and recrystallized three times from 80 per cent ethanol. The final product had a melting point of 194° C., corrected. Infra-red spectra of this material and authentic β-aminoethyl*iso*thiouronium dibromide obtained from Dr. D. G. Doherty were identical and a mixture melting point of the two was not depressed.

Female Sprague–Dawley rats weighing about 100 gm. were divided at random into six experimental groups of eight animals each and fed Rockland rat diet (1·20 mgm. iodide/100 gm. diet) *ad libitum*. The animals were given: (1) 400 mgm. β-aminoethyl*iso*thiouronium dibromide/kgm. body-wt./day; (2) 50 mgm. 6-propylthiouracil/kgm. body-wt./day; (3) 120γ L-thyroxine/kgm. body-wt./day; (4) 400 mgm. β-aminoethyl*iso*thiouronium dibromide + 120γ L-thyroxine/kgm. body-wt./day; and (5) 50 mgm. 6-propylthiouracil + 120γ L-thyroxine/kgm. body-wt./day by gavage daily as a freshly prepared suspension in 10 per cent gum acacia. A control group was given 10 per cent gum acacia alone. Daily weights were obtained. On the last day of drug administration, 0·05 μc. iodine-131 in 0·1 – 0·2 ml. solution was injected intraperitoneally. The animals were killed 24 hr. later, and the larynx with the thyroid gland attached was removed and assayed for radioactivity. The thyroid then was dissected carefully from the larynx and weighed.

The results are summarized in Table 1. The administration of β-aminoethyl*iso*thiouronium dibromide resulted in less iodine uptake and in some thyroid enlargement ($P < 0·05$). 6-propylthiouracil, which is known to be a powerful goitrogen, produced similar, though greater, changes. The increase in thyroid weight was prevented in both cases by the simultaneous administration of L-thyroxine. Thiourea derivatives are known to block the formation of thyroid hormone[2]. It is not surprising, therefore, that β-aminoethyl*iso*thiouronium dibromide, which is related structurally to these compounds, results in depression of iodine uptake and thyroid enlargement. While hypothyroid animals perhaps are somewhat more resistant to irradiation[3], the radiation protective action of β-aminoethyl*iso*thiouronium dibromide is greatest during the half-hour immediately following its administration, and in acute radiation experiments it is not likely that the anti-thyroid action of β-aminoethyl*iso*thiouronium dibromide explains any radiation protective action. However, it is of interest that cysteamine, another radiation protective compound, also has anti-thyroid activity[4].

Table 1. Effect of β-Aminoethyl*iso*thiouronium Dibromide (AET) and Propylthiouracil (PTU) on the Iodine Uptake and Thyroid Weight of Rats

Drug and dosage (10 days)	Average body-weights		Thyroid weight (mgm./100 gm. body-weight)	24-hr. radioiodine uptake (per cent)
	Initial (gm.)	Final (gm.)		
400 mgm. AET/kgm. daily	140	180	9·56 ± 1·0	3·64 ± 0·40
50 mgm. PTU/kgm. daily	160	210	16·0 ± 0·73	0·68 ± 0·18
120γ L-thyroxine/kgm. daily	160	200	6·06 ± 0·88	1·62 ± 0·48
400 mgm. AET + 120γ L-thyroxine/kgm. daily	135	190	7·14 ± 0·68	0·19 ± 0·04
50 mgm. PTU + 120γ L-thyroxine/kgm. daily	140	180	8·12 ± 0·74	0·25 ± 0·10
Control (10 per cent gum acacia)	140	190	7·62 ± 0·33	16·0 ± 1·0

This work was supported in part by a gift from the Smith, Kline and French Foundation.

John Osmer
Robert B. Jennings
Robert M. Dowben

Departments of Pathology and Medicine,
Northwestern University,
Chicago 11.
Nov. 28.

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Effect of Salicylate on Blood and Liver Xanthine Dehydrogenase of Rats

MILK and liver xanthine oxidase are inhibited by sodium salicylate *in vitro*[1]. Bergel *et al.*[2] were able to utilize this property for the stabilization of xanthine oxidase by adding salicylate to the process of purification of the enzyme.

Adult white rats of the Wistar strain were used for the determination of the *in vivo* effect of salicylate on blood and liver xanthine dehydrogenase. Rats were injected intraperitoneally by a single dose of 0·5 mgm. of sodium salicylate per gm. body-weight, and xanthine dehydrogenase activity on liver and blood serum determined 4 hr. after the injection by methods previously described[3].

Blood serum of normal rats showed values of 29·0 ± 6·9 µgm. formazan/ml. serum/30 min. at 37° C. In the injected rats the average value was 40·4 ± 5·4 µgm. formazan/ml. serum/30 min. These results show an increase of xanthine dehydrogenase activity which is statistically significant (normal, $t = 4{\cdot}2$, $P < 1$ per cent; injected, $t = 7{\cdot}4$, $P < 1$ per cent). 24 hr. after the injection, this value decreased to 25·2 ± 7·0 ($t = 3{\cdot}6$, $P < 2$ per cent). On the other hand, liver from injected rats presented a loss (82·67 per cent inhibition) in xanthine dehydrogenase activity (Table 1).

Table 1. EFFECT OF SALICYLATE IN RAT LIVER XANTHINE DEHYDROGENASE*

	Without dialysis		With dialysis	
	Mean	Range	Mean	Range
Normal	675	217–1,865	891	257–1,814
Salicylate	117	0– 366	254	128– 308
Inhibition (per cent)	82·67		71·50	

* µgm. formazan/gm. dry liver/60 min. at 37° C.

Since salicylate could be removed from the enzyme by dialysis, with full restoration of the enzyme activity[1] even after prolonged association[2], we were interested to know if this *in vivo* inhibition of rat liver xanthine dehydrogenase by salicylate was also restored by dialysis. Dialysis of liver homogenate against distilled water in the cold gave the results summarized in Table 1.

In vitro experiments with a final concentration of $M/10$ sodium salicylate showed an inhibition of rat-liver xanthine dehydrogenase activity (60–70 per cent inhibition) and also of the blood-serum enzyme (50–100 per cent inhibition).

The low restoration of xanthine dehydrogenase activity obtained by dialysis of liver homogenate (Table 1) from injected rats shows that the *in vivo* inhibition of the xanthine dehydrogenase activity is possibly not only due to a loose bond (split by dialysis) between the salicylate and the enzyme. Definitive liver damage occurs in rats given 400 mgm. of sodium salicylate/kgm./day[4]. Since the loss of enzyme protein from liver tissue seems to be a general phenomenon which accompanies cell destruction in certain conditions[5], it seems probable that with the dose used by us (500 mgm./kgm.) the flow of the liver xanthine dehydrogenase, which is a soluble protein[6], to the blood serum results in a decrease of the enzyme activity in liver and consequently an increase of the blood serum xanthine dehydrogenase activity.

We are indebted to Dr. G. G. Villela for his help and advice. This investigation was supported by grants from Conselho Nacional de Pesquisas.

EMILIO MITIDIERI
OTTILIA R. AFFONSO

Biochemical Laboratory,
Instituto Oswaldo Cruz,
Rio de Janeiro.
Dec. 3.

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Re-ingestion in *Lepus capensis* L. and *Ochotona roylei* Ogilby

THE domestic rabbit produces special soft fæcal pellets which are normally taken back into the stomach direct from the anus[1,2]. This behaviour, which has been termed coprophagy, refection[2] or more appropriately re-ingestion[3], has been observed in wild rabbits[4] where it has been shown to follow a regular daily rhythm, beginning about sunrise and ending in the early afternoon[3,5].

Re-ingestion, following a similar rhythm, has since been observed in *Lepus europaeus*[6], *L. californicus*[7], *L. townsendii*, *L. americanus* and *Sylvilagus transitionalis*[8], and evidence has been reported of re-ingestion in *S. palustris*[9] and *S. floridanus*[10].

The present communication reports the occurrence of re-ingestion in another leporid and the first report from the Ochotonidae, thus supporting Watson and Taylor's[6] suggestion that re-ingestion is a normal feature of lagomorph biology.

The material was collected from an ablation valley on the northern side of the Barpu Glacier, in the Gilgit Agency of Pakistan, at an altitude of 11,000–13,000 ft. The lower part of the valley was rough grassland where hares (*Lepus capensis*) were abundant, and higher up this was replaced by a juniper association (*Juniperus turkestanica* Korn) growing on boulder banks, where the pikas (*Ochotona roylei*) lived. Three pikas and 19 hares were shot at different times of the day and nine pikas were trapped at night.

Table 1 groups the 19 hares examined into 2-hr. periods from 0600 hr. to 2000 hr. Between 0800 hr. and 1400 hr. soft fæces were found in the recta, the criterion of active re-ingestion[3], and in some of these hares amorphous fæcal material was also found in the cardiac end of the stomach. In one hare, which had a tapeworm in the duodenum, a gravid proglottis was found with the fæcal material in the stomach. Since no hares were shot at night, these observations

Table 1. INCIDENCE OF RE-INGESTION IN *L. capensis*

Time	No. examined	No. with soft fæces in rectum
0600 hr.	1	0
0800	5	0
1000	3	1
1200	2	2
1400	5	5
1600	—	—
1800	—	—
2000	3	0
Total	19	8

are not sufficient to show the full rhythm; but the incidence of re-ingestion conforms closely to that reported for other species of *Lepus*.

Among the 12 pikas examined four had soft pellets in the rectum and six had soft pellets or amorphous material in the cardiac end of the stomach. In one animal hard pellets were seen in the rectum posteriorly and soft pellets near the colon, and in another soft pellets were seen near the anus and hard pellets near the colon, indicating that these two animals were respectively beginning and ending re-ingestion. The daily rhythm in *Ochotona* does not emerge from this material; but, since the three animals shot in the daytime did not have soft fæces in the rectum and four of the animals trapped at night did, re-ingestion in *Ochotona* may occur at night in contrast to the Leporidae so far examined.

C. H. Tyndale-Biscoe

Edwardes College,
Peshawar,
and
Department of Zoology,
University of Western Australia,
Nedlands.
Nov. 25.

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Ineffectiveness of Molybdenum, Osmium and Cobalt in Dietary Necrotic Liver Degeneration

In our past, comprehensive experience in the fractionation and purification of Factor 3 from various source materials, using the prophylactic rat test against dietary liver necrosis as an assay, it has been obvious that the Factor 3 effect was caused by a highly specific, potent, protective ingredient. The latter was recognized to be an organic selenium compound[1]; this, in turn, led to the realization that selenium is an essential micronutrient. Selenite-selenium was found to prevent necrotic liver degeneration, with a 50 per cent effective dose-level of 2·2 μgm. per cent and full protection at levels of approximately 5 μgm. per cent selenium in the diet. Factor 3-selenium is 3–5 times as potent[2].

Bunyan, Edwin and Green, on the other hand, have recently published preliminary results suggestive of protective effects of molybdenum, osmium and cobalt[3]. Their results stand in distinct contrast to earlier, unpublished results of our own. In 1953, for example, when it was discovered that molybdenum is essential for normal xanthine oxidase-levels in tissues[4,5], we had observed that 1 mgm. per cent of molybdic anhydride in the diet did not materially influence the development of dietary liver necrosis.

We have attempted to verify under our experimental conditions the findings of Bunyan and collaborators, with negative results (Table 1). Experimental details are described elsewhere[6,7]. The 30 per cent *Torula* yeast diet and weanling, inbred Fischer 344 strain of rats were employed, and the pre-depletion method was used, that is, the animals were kept for 13 days on the basal diet before start of the supplementation of test-substances. Molybdenum, osmium and cobalt, either alone or in combination, were tested at various dose-levels. They were without effect against liver necrosis even at 200, 200 and 400 μgm. per 100 gm. of diet, respectively.

Table 1. INEFFECTIVENESS OF MOLYBDENUM, OSMIUM AND COBALT IN DIETARY NECROTIC LIVER DEGENERATION

Supplement	Element μgm. per cent in diet	No. of rats		Average velocity*
		Total	Survivors on 30th day	
Sodium selenite†	controls	44	4	4·45
	2	20	11	1·90
	4	10	9	0·36
	10	20	20	0
Ammonium molybdate	controls	10	1	4·4
	50	10	2	4·0
	100	10	0	4·8
	200	10	1	4·7
Osmium tetroxide	controls	37	2	4·7
	50	10	1	4·3
	100	18	1	4·8
	200	10	0	4·8
Cobaltous acetate	controls	20	2	4·5
	50	10	2	3·9
	100	18	3	4·3
	200	10	1	4·4
	400	18	2	4·2
Combination of ammonium molybdate, osmium tetroxide and cobaltous acetate	controls	20	2	4·2
	25+50+50	10	1	4·6
	50+100+100	10	2	4·1
	100+200+200	19	2	4·5

* Group average of reciprocals of individual survival-times (× 100). All experiments were terminated on the thirtieth day, and velocity of 0 was assigned to survivors.

† Published previously (ref. 2).

The question arises as to what possible cause there may be for the discrepancy between the results of Bunyan *et al.* and ours. It is our experience that differences such as those reported by Bunyan *et al.* are not significant if they are not consolidated by repetition of the experiment. However, the authors observed at least the delaying effect of the *combination* of the three trace elements twice. The statistical validity of such results can be assessed if the velocity of the development of the disease (V_{st}) is calculated for each group by computation from the individual reciprocals of the survival times[6]. For animals surviving indefinitely, $V_{st} \rightarrow 0$. Among various alternative explanations, the three trace elements may act through influencing appetite. Results available on the toxicity of molybdenum, osmium and cobalt salts are sporadic, but it appears that the doses used by Bunyan *et al.* are below those reported by others to be toxic. However, it must be kept in mind that the minimum chronic toxic dose-levels vary considerably with the general composition of diets. A restriction of dietary intake, or its reduction by other means such as chronic poisoning, delays or completely prevents the development of liver necrosis[8]. A chronic, toxic influence could make itself felt more effectively in their studies than in ours, since they require on the average 55–60 days for the production of liver necrosis, with a wide range of survival-times, and survivors in the control groups even at the hundredth day. This compares with an average survival-time of 21 days under our conditions, with much less statistical variation but small numbers of survivors after 30 days. Our animals died approximately 8 days after the start of the supplementation of the trace element. Food consumption was measured in 10 of the groups listed in Table 1. There were no significant differences. Interaction between the trace elements and some essential ingredient in the diet may also play a part. The explanation that molybdenum, osmium and cobalt act through participation in oxidation-reduction mechanisms within the organism, thus alleviating the defect existing in intermediary metabolism under pre-necrotic conditions[9], also may pertain, as mentioned by Bunyan *et al.*

It is obvious from our findings, however, that molybdenum, osmium and cobalt are not of primary importance in the prevention of dietary necrotic liver degeneration. If they have a moderating influence at all, it would be of a secondary nature.

KLAUS SCHWARZ
EDWARD E. ROGINSKI
CALVIN M. FOLTZ

Laboratory of Nutrition and Endocrinology,
National Institute of Arthritis and
Metabolic Diseases,
National Institutes of Health,
Bethesda, Maryland.
Dec. 3.

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Fractionation of Brain Extracts for Acid Phosphatase-elevating Activity

IN a previous communication[1] it was demonstrated that *in vitro* incubation of rat pituitary with whole aqueous hypothalamic extract increased acid phosphatase activity in the pituitary gland. Temporal lobe extract had no such effect. The results of a study of the effect of individual fractions of the extracts are given below.

Ten excised portions of the base of rabbit brains (median eminence, base of the third ventricle and the adjacent parts; below, hypothalamus), with a total weight of 3·33 gm., were homogenized in 50 ml. 0·45 per cent sodium chloride solution and frozen at − 20° C. The following day the insoluble material was separated by centrifugation at *p*H 6·8 and the extract was divided into the following three fractions, which were lyophilized: (I) *p*H 6·8–7·0, 25 per cent ethyl alcohol; (II) *p*H 4·8 ± 0·1, 40 per cent ethyl alcohol; (III) lyophilizate of the residue (low molecular substances). Aliquots of the individual fractions, corresponding to 1/10 of a rabbit hypothalamus, were mixed with 0·5 ml. distilled water containing homogenate of 1/3 rat pituitary gland, and acid phosphatase activity was determined in the mixture by the King–Armstrong method, at *p*H 5·3. Activity was expressed as King–Armstrong units/gm. pituitary (Table 1). Acid phosphatase activity of the homogenate was elevated only by the third (non-protein) fraction of hypothalamic extract. Fraction III did not itself contain acid phosphatase.

Although in the preceding experiments[1] crude temporal lobe extract had no effect on acid phosphatase activity in the pituitary gland, a further series of experiments was carried out, in which fraction III was prepared in the same way from hypothalamus and from temporal lobe. Ten rabbit hypothalami weighing 3·54 gm. yielded 200 mgm. of fraction III, and ten portions of temporal lobe weighing 3·73 gm. yielded 205 mgm. In both cases the brains were homogenized in 0·225 per cent sodium chloride solution. Equivalents of 1/10 or 1/20 of one excised brain portion were again mixed with 0·5 ml. pituitary homogenate and acid phosphatase activity expressed in King–Armstrong units/gm. (Table 2). The factor elevating acid phosphatase activity in pituitary homogenate is present in fraction III of both the hypothalamus and temporal lobe extract. In the latter it is discernibly lower.

In the final experiment in this series the influence of fraction III of both brain extracts on the acid phosphatase activity of other tissues was determined. 50 mgm. rat liver or kidney was homogenized in 10 ml. water; 0·5 ml. of this homogenate was then mixed with amounts of fraction III corresponding

Table 1

Fraction	0	I	II	III	III (without homogenate)
No. of experiments	18	14	10	10	6
Mean acid phosphatase activity (King–Armstrong units/gm. ± σ_m)	1·88 ± 0·108	1·23 ± 0·082	1·11 ± 0·296	2·86 ± 0·114	0·0 ± 0·0

Table 2

Origin of the low-molecular fraction and concentration (equivalents of one part of brain)	0	Hypoth. 1/10	L. temp. 1/10	Hypoth. 1/20	L. temp. 1/20
No. of experiments	30	12	12	18	17
Mean acid phosphatase activity (King–Armstrong units/gm. ± σ_m)	1·76 ± 0·12	4·32 ± 0·114	3·66 ± 0·147	2·82 ± 0·162	2·08 ± 0·150

Table 3

Homogenate of	Liver			Kidney		
Origin of the low-molecular fraction	0	Hypoth.	L. temp.	0	Hypoth.	L. temp.
No. of experiments	8	8	7	8	8	4
Mean acid phosphatase activity (King–Armstrong units/gm. ± σ_m)	3·52 ± 0·133	6·37 ± 0·252	5·20 ± 0·151	2·81 ± 0·420	4·64 ± 0·420	6·40 ± 0·0

to 1/10 hypothalamus or temporal lobe. Acid phosphatase activity was again expressed in King–Armstrong units/gm. fresh tissue in the homogenate (Table 3). Fraction III of the brain extracts also raised acid phosphatase activity in liver and kidney homogenate.

No explanation has yet been found for the discrepancy between the effect of fraction III of the temporal lobe extract and the ineffectiveness of crude aqueous extract of this lobe. In spite of the obvious non-specificity of the acid phosphatase-elevating activity of the fraction III of hypothalamic extract, we cannot exclude the possibility that the active factor is a hypophysiotrophic hypothalamic hormone. It is probable[2] that it is linked with the production of the thyrotrophic hormone of the pituitary gland.

V. SCHREIBER
J. CHARVÁT
V. KMENTOVÁ

Third Medical Clinic,
Laboratory for Endocrinology
and Metabolism,
Charles University,
Prague.

M. RYBÁK

Research Institute for
Hæmatology and Blood Transfusion,
Prague.
Dec. 2.

---

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Failure of Acetylcholine Release in Tick Paralysis

A MOTOR paralysis can be caused in a number of mammalian species, including man, by the continued attachment of the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles[1]. The symptoms are manifested as a flaccid paralysis which begins in the hind limbs and ascends until ultimately the bulbar respiratory centres are involved.

Of the common laboratory animals, only dogs, guinea pigs and hamsters are subject to paralysis following the bite of this tick, and they are not invariably affected. We, and Gregson[2], have found that the only animal which has always been affected is the ground hog *Marmota flaviventris avara* (Bangs), the only variable being the time taken for the symptoms to appear. This latter is apparently dependent upon the number of attached ticks and their rate of feeding. The experiments to be described here have all been performed on ground hogs, using ticks that were collected from their natural environment in the vicinity of Kamloops, British Columbia. The animals show the typical picture of an ascending flaccid paralysis which ultimately involves the muscles of respiration. The only inconsistency in this progression of the condition is that very early the normal piercing cry of the animal is lost and is replaced by a hoarse grunt, seemingly due to involvement of the vocal cords. Another characteristic feature of tick paralysis as evidenced in most animals is the rapid disappearance of the symptoms following removal of the tick. This is not true of the condition in ground hogs in which death frequently ensues once the paralysis has become evident, even though the tick is removed. There is good evidence that the paralysis is not caused by the transmission to the host of a virus or of a micro-organism, but that it is due to a toxin secreted by the tick[1].

There can be little doubt that there exists in this condition a peripheral neuromuscular block. This has been shown by Rose and Gregson[3] and by Murnaghan[4] to be true in other animals; and we, as well as Gregson[2], have confirmed it in ground hogs. Adult ground hogs were paralysed 18–36 hr. after 4–7 partially engorged female ticks were allowed to attach themselves, and experiments were conducted at a time when respiratory difficulty first became noticeable. Records of the twitches of the gastrocnemius, tibialis anterior and brachialis muscles have been made following maximal electrical stimulation of the appropriate motor nerves, and the tensions developed in the muscles of fully paralysed animals are never more than 5 per cent of those found in controls. The response to repetitive stimulation (twenty impulses per sec.) is poorly maintained, and there is no evidence of a post-tetanic potentiation of the response to a single shock such as may be attained in a partially curarized preparation. The muscles remain directly excitable throughout.

Murnaghan[4] has reported that in one fully paralysed dog the threshold dose of acetylcholine required to produce a muscle twitch following intra-arterial injection was much reduced, resembling the enhanced sensitivity found after denervation. We have failed to confirm this in four fully paralysed ground hogs. The concentrations of acetylcholine required to elicit a detectable electromyographic response (recorded with a concentric needle electrode) was the same for both control and paralysed animals.

Perfusion of the hind limb of ground hogs was achieved following cannulation of the common iliac artery and vein. A 'finger' pump was used to give a pulsatile flow of the perfusion medium, which consisted either of reconstituted human serum or Tyrode's solution, both equilibrated with 95 per cent oxygen–5 per cent carbon dioxide and containing 10 mgm./l. of eserine sulphate. The main trunk of the sciatic nerve was maximally stimulated at a frequency of 10/sec. Acetylcholine was assayed by observing the ability of the effluent perfusion fluid to depress the blood pressure of the eviscerated cat.

The results, which are shown in Table 1, indicate clearly that in the paralysed animals there is a lack of release of acetylcholine into the perfusion fluid as a response to stimulation of the sciatic nerve. Whether this failure is due to a deficient synthesis of acetylcholine or to an impaired release of the substance from the endings of the motor nerves must await further investigation. In either event, however, it is difficult to allow that this peripheral action brought about by

Table 1. RELEASE OF ACETYLCHOLINE IN PERFUSED GROUND HOG LIMBS.
Acetylcholine gm./min. × 10^{-9}

	Unstimulated			Stimulated		
	First 5-min. period	Second 5-min. period	Third 5-min. period after stimulation	First 5-min. period	Second 5-min. period	Third 5-min. period
Normal	6·8	2·1	0	46	28	11
	0	0	1·4	12	13	8·2
	8·9	10	—	25	—	—
Paralysed	4·0	4·1	0	4·6	4·6	3·3
	0	0	0	3·4	0	0
	1·9	3·1	5·3	5·6	7·1	8·0
	0	7·0	0	0	0	0

the tick toxin can be the only one. *A priori* there seems no reason why any given muscle should be preferentially affected, and one would expect to see a gradual generalized weakening of the skeletal musculature rather than the orderly ascending progression of paralysis which is the observed fact. We conclude that in addition to the peripheral, there is likely to be some central nervous system component to the syndrome which is as yet undefined.

PATRICIA EMMONS
H. MCLENNAN

Department of Physiology,
University of British Columbia,
Vancouver, B.C.
Dec. 8.

[1] Mail, G. A., and Gregson, J. D., *Canad. Med. Assoc. J.*, 39, 532 (1938).
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Colloid Osmotic Pressure of Rheumatoid Synovial Fluid

THE colloid osmotic pressure of rheumatoid synovial fluid samples was measured before and after intra-articular hydrocortisone treatment using collodium membranes and a hydrostatic compensation system[1]. Previously, it had been found that contents of vacuum-dried synovial fluid adsorbed decreased volumes of water after cortisone treatment[2]. The results are presented in Tables 1 and 2, but a detailed account on the material is given elsewhere[3].

Table 1. CHANGES OF COLLOID OSMOTIC PRESSURE (IN CM. WATER) OF RHEUMATOID SYNOVIAL FLUID IN CONNEXION WITH HYDROCORTISONE TREATMENT

Clinical effect	No. of cases	Treatment Before	Treatment After	Difference	P
Poor	6	42·3	38·2	−4·1	0·05
Moderate	7	42·3	38·0	−4·3	0·05
Excellent	11	42·4	33·0	−9·4	0·001
All cases	24	42·4	35·7	−6·7	0·001

Table 2. COLLOID OSMOTIC PRESSURE (IN CM. WATER) OF SYNOVIAL FLUID AND SIZE OF THE EFFUSION (CASES OF STAGES I–II ONLY; $P < 0\cdot05$ WITH ANALYSIS OF VARIANCE)

Size	No. of cases	Mean and range	
Moderate	7	41·8	(38–46)
Large	8	44·3	(40–58)
Very large	6	46·3	(42–51)

The colloid osmotic pressure could be correlated with the total protein ($r = 0\cdot66$; $P < 0\cdot001$) and with the blood erythrocyte sedimentation rate ($r = 0\cdot70$, $P < 0\cdot001$) but not with the concentration of synovial fluid sodium, potassium, chloride or hyaluronate or with the intrinsic viscosity. With the size of effusion a relation could be established only in the cases of Stages I–II (roentgenologically non-advanced).

It is concluded that the changes in the protein concentration and consequently in the colloid osmotic pressure of the synovial fluid are of importance in the formation and disappearance of the effusion. It may be argued that if the protein actually passes into the synovial cavity, its colloid osmotic pressure cannot have any significance. Admittedly, in the genesis of traumatic effusions a permeability damage is more important, and in the anatomically more advanced cases with stiff joints the colloid osmotic pressure is generally lower ($P < 0\cdot001$) and seems immaterial. However, submitting the observed clinical and chemical correlations as circumstantial evidence, we suggest that the increased colloid osmotic pressure may prevent the normal resorption of fluid from the synovial cavity in rheumatoid arthritis.

The polysaccharide does not seem important in the maintenance of the colloid osmotic pressure. The significance of the qualitative and quantitative changes in the hyaluronate should be sought from the analogies with the connective tissue response to inflammation.

The financial support from the Sigrid Jusélius Foundation is gratefully acknowledged.

PAAVO MÄKINEN
EINO KULONEN

Department of Medical Chemistry,
University of Turku,
Turku, Finland.
Dec. 5.

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Inactivation of Spores of *Bacillus anthracis* by γ-Radiation

THE bactericidal effect of ionizing radiation has been recognized for many years; but it is only recently that serious attention has been given to this method of sterilization for foodstuffs[1] and for pharmaceutical and other products[2,3]. This is due mainly to the increased availability of radioactive isotopes. In this respect γ-radiation seems to be the most useful due to its effective depth of penetration, and the most convenient sources of γ-radiation are cobalt-60 and cæsium-137.

The present communication records the results obtained from a preliminary investigation into the sterilizing efficiency of γ-radiation against spores of *Bacillus anthracis*. Eight strains of *B. anthracis* were used.

Spore suspensions were prepared by inoculating 5 ml. of 'Yeastrel' broth with the test organism; after incubation for 72 hr. the culture was heated at 60° C. for 30 min. The approximate number of viable spores remaining was determined by adding 0·1 ml. of the heated suspension to 100 ml. of broth and then spreading 0·1 ml. of the diluted material over the surface of a dish of 'Yeastrel' agar. If at least 100 colonies grew, this indicated a viable count of at least 10^6 spores/ml. and the suspension was used in the experiment. If less than 100 colonies grew, the suspension was rejected and another culture prepared.

Approximately 0·5 gm. samples of washed goat hair were compressed in test-tubes 15 cm. × 1·5 cm., stoppered with cotton-wool plugs and sterilized by autoclaving at 15 lb./sq. in. for 15 min. Each sample of hair was contaminated by adding to the tube 1 ml. of a spore suspension in broth of the test organism. The samples were then dried at 56° C. for 48 hr. and allowed to stand in the incubator at 22° C. for 4 weeks.

Samples of contaminated hair were treated with increasing doses of γ-rays from a cobalt-60 source. The dose-rate was varied (from 10^4 rad/hr. to

2×10^5 rad/hr.) by altering the distance of the samples from the source. All irradiations were carried out at room temperature, and doses are given with a maximum error of ± 5 per cent.

In a pilot experiment six of the eight strains of *B. anthracis* were used. Each organism was exposed to radiation from a cobalt source at 200,000 rad/hr. for periods of 3, 7, 9 and 15 hr. (actual doses: 0·58, 1·42, 1·80 and $3{\cdot}0 \times 10^6$ rad).

After irradiation, each tube was tested for sterility by adding 10 ml. of 'Yeastrel' broth and incubating at 37° C. for 2 and 28 days.

Tubes which had not been irradiated were included as controls and all these showed growth in 48 hr. Similarly, growth was obtained in 48 hr. in all tubes exposed to a radiation dose of $0{\cdot}58 \times 10^6$ rad, but all other tubes were sterile even after 28 days incubation (Table 1).

Table 1. VIABILITY OF SPORES AFTER γ-RADIATION

B. anthracis strain	Radiation dose ($\times 10^6$ rad)				
	0·0*	0·58	1·42	1·80	3·0
1	+	+	–	–	–
2	+	+	–	–	–
3	+	+	–	–	–
4	+	+	–	–	–
5	+	+	–	–	–
6	+	+	–	–	–

* Control; +, growth after 48 hr.; –, no growth after 28 days.

A second experiment was carried out using these six strains of *B. anthracis*, together with two others, more recently isolated (kindly supplied by Prof. D. T. Robinson, Liverpool Public Health Laboratory). The organisms were exposed to a graded series of radiation doses varying from $0{\cdot}8 \times 10^6$ rad to $2{\cdot}1 \times 10^6$ rad. The accuracy of the radiation dose was again ± 5 per cent.

In a third series, the two recently isolated strains were irradiated in the range $1{\cdot}0\text{–}1{\cdot}4 \times 10^6$ rad.

The results of all three series are combined in Table 2.

Table 2

B. anthracis strain	Radiation dose ($\times 10^6$ rad)											
	0*	0·8	0·9	1·0	1·1	1·2	1·35	1·4	1·5	1·7	1·9	2·1
1	+	+	+	+	+	+	+	+	–	–	–	–
2	+	+	+	+	–	–	–	–	–	–	–	–
3	+	+	+	–	–	–	–	*NT*	–	–	–	–
4	+	+	*NT*	*NT*	*NT*	*NT*	*NT*	–	*NT*	*NT*	*NT*	*NT*
5	+	+	+	+	+	–	–	–	–	–	–	–
6	+	+	+	+	–	–	–	*NT*	–	–	–	–
7	+	*NT*	*NT*	+	+	+	*NT*	–	*NT*	*NT*	*NT*	*NT*
8	+	*NT*	*NT*	+	+	–	*NT*	–	*NT*	*NT*	*NT*	*NT*

* Control; +, growth after 48 hr.; –, no growth after 28 days; *NT*, not tested at this level.

From this it will be seen that the most sensitive strain of *B. anthracis* failed to grow after $1{\cdot}0 \times 10^6$ rad while the most resistant needed $1{\cdot}5 \times 10^6$ rad for inactivation.

These experiments were carried out with the view of determining the applicability of γ-radiation to the sterilization of imported goat hair. In the United Kingdom this substance is at present subjected to a formaldehyde treatment as laid down in the Anthrax Act of 1919.

On the basis of our results a dose of $1{\cdot}5 \times 10^6$ rad is sufficient to ensure the inactivation of a high concentration of spores of all the strains of anthrax used. Further experiments are in hand using a larger number of strains to find more certainly the natural variation in radiation resistance. Pending the completion of the experiment we suggest that a minimum dose of $2{\cdot}0 \times 10^6$ rad would provide a sufficient margin of safety in an industrial process for the inactivation of *B. anthracis* in baled goat hair.

T. HORNE

Wantage Radiation Laboratory,
Isotope Division,
Atomic Energy Research Establishment,
Harwell.

G. C. TURNER
A. T. WILLIS

Department of Bacteriology,
School of Medicine,
Leeds.

Dec. 12.

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Phagocytosis and Cell Division

MOST investigators believe that reticulo-endothelial cells, through ingestion of the antigen, play an initial part in the synthesis of antibody[1,2]. Study of phagocytosis of particulate antigens lends support to this concept[3]. Since antibody is merely one form of protein, its formation could theoretically occur immediately; however, it appears to be delayed several hours or days[4].

It has recently been thought that when antibody does appear it is most closely associated not with the reticulo-endothelial cell but with the plasma cell[5], although lymphocytes[6] and eosinophils have also been implicated[7].

Some investigators believe that plasma cells and lymphocytes are derived from reticulo-endothelial cells and that during the process of division and differentiation the antibody-producing mechanism is automatically transferred to the daughter cell[8]. However, other workers feel that some way other than division must be postulated to explain transfer of the antibody stimulus from the reticulo-endothelial cell to the plasma cell. They point out that cells which have ingested large quantities of carbon are unable to divide, and conclude that reticulo-endothelial cells after ingestion of the antibody could not divide and differentiate into plasma cells[9].

While studying the process of phagocytosis in L strain fibroblasts, we made some observations which may be applicable to this problem. These cells were grown routinely in suspension tissue culture as single cells, in Eagle's medium and 10 per cent horse serum as described previously[10]. Cultures (70 c.c. in volume) were incubated for 1 hr. at 37·5° with 1 mgm. carmine particles. Following incubation, the cells were washed free of carmine and resuspended in fresh medium. If the incubation was continued for 3 hr., the cells ingested a great many carmine particles and were unable to divide, and the cells usually died over a period of 3–5 days. However, cells which had ingested only 3–6 carmine particles per cell underwent normal division with a generation-time of approximately 28 hr., similar to the control cultures. No abnormal mitotic figures were noted, and the particles distributed themselves in the cytoplasm during mitosis (Fig. 1).

Some investigators believe that fibroblasts and macrophages are derived from reticulo-endothelial cells and that they may revert to their original form[11].

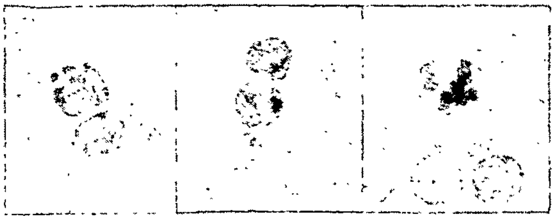

Fig. 1. Several fibroblasts have phagocytized carmine granules. Two cells are in anaphase. Aceto-carmine stain. (× 450)

Regardless of the truth of this statement, our experiments show that a phagocytic cell may ingest large amounts of foreign material and afterwards undergo division. By analogy, it lends support to those who believe that the phagocytic reticulo-endothelial cell may ingest a foreign protein antigen and retain the ability to divide. If a reticulo-endothelial cell does differentiate into a plasma cell, these observations also support the unified concept of ingestion of antigen and production of antibody within a single cell.

This investigation was supported by a grant from the U.S. Public Health Service *C*2928(*C*).

KLAUS G. BENSCH
STANLEY SIMBONIS
ROLLA B. HILL, JUN.
DONALD W. KING

Department of Pathology,
Yale University School of Medicine,
New Haven, Connecticut.
Dec. 1.

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Inhibitory Action of Amino-Acid Esters on the Production of Extracellular Amylase by *Penicillium chrysogenum*

WASHED mycelium of *Penicillium chrysogenum* will not synthesize amylase except in the presence of starch. Production cannot be increased by adding amino-acids to the medium.

Amylase production by the mycelium of washed *Penicillium chrysogenum* strain Wis. 49–133 was studied. The mould was grown for 48 hr. in a medium containing soluble starch. The dry-matter content was 0·62 gm./100 ml. of incubated medium. The experimental conditions were as follows: *Penicillium chrysogenum* was grown at 24° C. in 200 ml. of medium in a 500-ml. Erlenmeyer flask on a rotary shaker (300 r.p.m., 2 cm. radius). The medium for the inoculum was composed of (per cent) glucose, 2; sodium nitrate, 3; potassium dihydrogen phosphate, 0·1; $FeSO_4.7H_2O$, 0·1; $MgSO_4.7H_2O$, 0·05; potassium chloride, 0·05; it was adjusted to *p*H 6·5 before sterilization and 0·5 per cent calcium carbonate was added before inoculation. The flasks were inoculated with a spore suspension. Mycelium was produced in the same medium. The energy source varied, but the concentration was always 2 per cent. Inoculations were carried out with 3-day-old inoculum. Mycelium production lasted for 48 or 72 hr., depending on the source of energy. Washing was done with 6 vol. of distilled water with filtering. The dry-matter content was determined by drying at 105° C. after filtering and washing with acetic acid. Enzyme production proceeded on a rotary shaker at 24° C. Mycelium suspended in 50 ml. of distilled water and 25 ml. of distilled water, or the indicated substance dissolved in distilled water, was added to 25 ml. of 0·4 per cent potassium dihydrogen phosphate and 0·4 per cent soluble starch (adjusted with potassium hydroxide to *p*H 6·5 before sterilization), in a 500-ml. Erlenmeyer flask. Amylase was determined in filtered samples of the incubated medium at 28° C. using the method of Smith and Roe[1]. Every step of the experiments was carried out under aseptic conditions and was afterwards tested for sterility.

Table 1 illustrates enzyme production as a function of time. The results are typical of induced enzyme synthesis. Identical results were obtained with mycelium grown on a wide variety of energy sources (glucose, lactose, sorbitol and glycerol), and most strikingly, even when the mould had been grown in a medium containing starch. Amino-acid esters have been found to be capable of inhibiting this enzyme production. Table 1 shows experiments carried out with glycine ethyl ester. Results similar to these were obtained with D-phenylalanine methyl ester and L-*iso*leucine methyl ester. A mixture of glycine and ethanol corresponding to a 10^{-2} *M* concentration of glycine ethyl ester, 10^{-2} *M* glycine amide and 10^{-2} *M* glycylglycine ethyl ester, were found to have no effect on enzyme production. The washed mycelia of mould, grown on various energy sources, all displayed the same behaviour in our inhibition experiments.

Table 1

Time (hr.)	Amylase (U/100 ml.)					
	Glycine ethyl ester hydrochloride (*M*)				Glycine and ethanol (see text)	
	10^{-2}	5×10^{-3}	10^{-3}	5×10^{-4}		
0	3	1	1	1	0	0
2	0	1	2	0	0	0
4	1	2	20	27	28	31
6	4	13	92	139	148	156
8	9	22	127	155	207	201
10	9	24	114	166	198	195
12	8	19	105	164	198	196
14	10	20	108	176	206	204
16	7	19	98	163	206	206

The activated carboxyl groups of the amino-acids should take part in the synthesis of peptides. These activated carboxyl groups are capable of reacting with hydroxylamine giving rise to hydroxamic acid[2,3]. Like hydroxylamine, the amino-group of the amino-acid esters possesses a marked reactive capacity.

I. HORVÁTH
S. BAJUSZ
A. SZENTIRMAI

Research Institute of the
Pharmaceutical Industry,
Budapest.
Nov. 25.

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Appearance of a Phosphorus Compound in Platelet-rich Plasma on Clotting

PREVIOUS experiments have shown that when clotting begins in human plasma containing platelets ('platelet-rich plasma'), adenosine triphosphate rapidly disappears from platelets with little or none of it appearing in the serum[1]. Other experiments suggested that in such plasma a phospholipoprotein is formed which is later broken down, and that this may be plasma thromboplastin[2].

Under the conditions used in those experiments fibrin appeared 5–10 min. after citrated plasma was recalcified. Since then a technique has been developed which leads to the formation of the clot within 2 min. With this technique the activity of thromboplastin in plasma reaches its maximum within 5 min. During that time there is not only a considerable breakdown of platelet adenosine triphosphate but also the appearance of a water-soluble phosphorus compound. This compound is the product of the breakdown of either phospholipid or phosphoprotein in the plasma.

To demonstrate this we made use of blood obtained from patients suffering from polycythæmia vera. The patients were being treated with phosphorus-32; some of this was incorporated into their plasma phospholipids and phosphoproteins which became radioactive. We observed the fate of this radioactivity during clotting. A representative experiment was as follows:

A male patient aged seventy-two was given 5 mc. of phosphorus-32 intravenously. After 48 hr., 200 ml. of blood was obtained from an arm vein and mixed with 4 ml. of 19 per cent (w/v) sodium citrate. The blood was centrifuged at 1,500*g* and 0–1° C. for 20 min. The plasma was removed and centrifuged at 22,000*g* for 15 min. to sediment the platelets. The supernatant platelet-free plasma (40 ml.) was dialysed at about 4° C., first against 3 l. Krebs–Ringer phosphate solution for 2 hr., and then for 18 hr. against 3 l. Krebs–Ringer bicarbonate solution modified so as to contain no phosphorus[2] and no glucose. The reason for dialysing against the phosphate solution was to reduce the specific activity of exchangeable phosphorus, and against the bicarbonate solution to reduce the concentrations of water-soluble phosphorus compounds in the plasma. After dialysis the concentration of inorganic phosphorus in plasma was 6·0 μgm./ml. and its specific activity was 0·6 counts/min. μgm. The specific activity of the plasma phospholipids was 14·7 and that of the plasma phosphoproteins 10·7 counts/min. μgm. phosphorus.

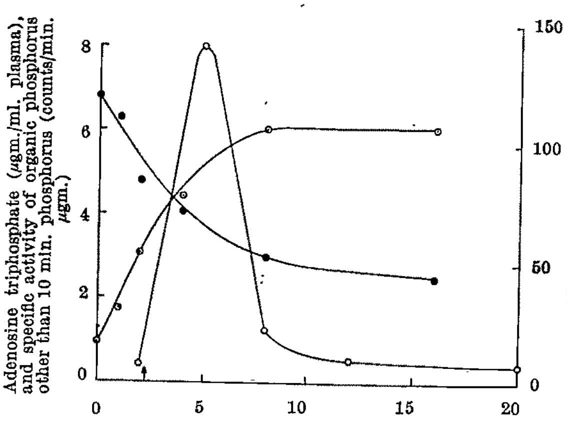

Fig. 1. Changes in the concentration of thromboplastin (○) and of adenosine triphosphate (●), and in the specific activity of organic phosphorus other than 10 min. phosphorus (⊙), in platelet-rich plasma during clotting. Calcium chloride was added at 0 min., and the clot formed after 2·3 min. as shown by the arrow

Samples (5 ml.) of dialysed plasma were incubated at 37° C. in glass tubes, the inner walls of which had been roughened by grinding. Platelets obtained from a healthy person were mixed with the plasma and 0·125 ml. *M* calcium chloride was added to each sample. The activity of thromboplastin was assayed at intervals of a few minutes. After 0, 1, 2, 4, 8 and 16 min., 1 ml. of 60 per cent (w/v) trichloracetic acid was added to a tube and thoroughly mixed with the clotting plasma. The tubes were cooled in ice and centrifuged at 0° C. for 5 min. at 22,000*g*. The clear supernatant solutions were decanted and retained. The precipitates were re-extracted with 5 ml. 10 per cent trichloracetic acid and the extracts were added to the first supernatants. The solutions were analysed for adenosine triphosphate by the firefly method[3]; and for inorganic phosphorus, organic phosphorus set free by *N* hydrochloric acid in 10 min. at 100° C. (10 min. phosphorus), and total phosphorus by the method of Berenblum and Chain[4]. The radioactivity of the phosphorus fractions was determined and expressed as counts/min. μgm. phosphorus.

The results are shown in Fig. 1. The activity of thromboplastin increased steeply after 2 min., reached a maximum after 5 min. and then decreased almost equally rapidly. Adenosine triphosphate began to disappear within the first minute after the addition of calcium, and continued to do so at a decreasing rate for 16 min. At the time when the activity of thromboplastin was maximal almost half of the adenosine triphosphate had gone.

Also within the first minute there was an increase in the radioactivity of the trichloracetic acid solutions. This radioactivity continued to increase for about 8 min. and then remained constant. It was accounted for by an increase in the specific activity of organic phosphorus other than 10 min. phosphorus, which rose from 0·95 to 6·03 c./min. μgm. phosphorus. Since only the phospholipids and phosphoproteins had specific activities higher than this, the radioactive organic phosphorus which appeared in the trichloracetic acid solution must have originated from one or the other.

Five other experiments of this kind gave similar results. It may be concluded that, as thromboplastin is formed in plasma during clotting, plasma phospholipid or plasma phosphoprotein is broken down with the liberation of an acid-soluble substance containing phosphorus.

We wish to thank Prof. L. J. Witts and Dr. Sheila Callendar for allowing us to obtain samples of blood, Dr. A. A. Sharp for collecting the samples, and Dr. W. D. McElroy for giving us fireflies.

G. V. R. BORN
M. P. ESNOUF

Nuffield Institute for Medical Research,
University of Oxford.
Jan. 23.

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Broadening of the X-ray Diffraction Lines in Teeth affected by Fluorine

THE diffraction of X-rays in the case of teeth can be investigated by a modification of the standard X-ray powder method, by producing biophysical specimens in the form of wires of tooth material by the careful cutting and filing of suitable pieces of tooth material. A 9 cm. camera of the Van Arkel type with filtered copper radiation has been used in comparing the diffraction lines from two specimens of teeth (one from a male and one from a female) which had been extracted following decay.

One of the teeth described had been surface-treated by a fluorine dental treatment approximately eight years previously, while the natural age of both teeth was similar. Cutting and filing was carried out so as to produce specimens of identical sizes, and such that one side in each case consisted of undamaged enamel: the resulting diffraction photographs are shown in Fig. 1 and it is seen that apart from the progressive broadening and blurring of higher-order lines in one photograph (from the specimen affected by fluorine, *a*), the patterns are identical.

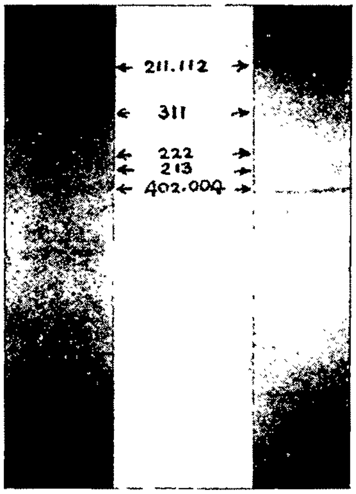

Fig. 1

The positions of the strongest lower-order diffractions were found to correspond with the hexagonal apatite form of crystal structure[1,2]. Since the teeth in their natural life must have experienced appreciable mechanical force and work of deformation, it is considered that a suggestion for the line-broadening based on normal stress/strain or grain size is less satisfactory than one arrived at by considering the variation of the surface composition within the cell-dimension limits of fluoro-apatite and chloro-apatite. This X-ray effect in hexagonal crystals has been previously described by one of us[3].

We are grateful to the Chemistry Department of the University of Sheffield for making available X-ray facilities.

E. A. SCOTT
F. H. SCOTT

5 Heather Lea Avenue,
Dore,
Sheffield.

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BIOLOGY

Triple Coitus in the Mealy Bug, *Planococcus citri* (Risso)

MALES of the mealy bug, *Planococcus citri*, do not feed throughout their nymphal stages of development nor after they emerge as adults. They are, nevertheless, highly active in mating during the few days of their short life as mature individuals. James[1] has observed that a single male may copulate with as many as 23 females in succession, and the average number of females fertilized by 13 individual males was 9·07. During my experience with mealy bugs cultured in the laboratory on potato, the observation has been made many times that two males will copulate simultaneously with one female while yet a third male may be attempting to do the same.

The fully winged males are quite sedentary, seldom fly, but crawl about on the potato in search of mature females. During the mating process, the females usually remain in the same spot at which they had previously settled in order to feed. It has not yet been possible to tell why a certain female in a group of equally old females attracts the males nor is it known how long after one mating the female remains attractive to males.

Simultaneous unions of two males with one female can be accomplished because of their relatively long abdomina. Usually the two males align themselves on the dorsal surface of the female; the abdomina and copulatory stylets then curve ventrally around the posterior limits of the female and both copulatory stylets and phalli penetrate the single vulva to the same extent. Both insertions are maintained by the males through considerable disturbance with a camel-hair brush, as is the case in pair matings. It is very likely, on the basis of this observation, that both copulations are genuine and that both mating acts are complete.

WALTER A. NELSON-REES
Genetics Department,
University of California,
Berkeley 4. Dec. 4.

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Behaviour of Sacculinized Shore Crabs (*Carcinus maenas* Pennant)

For some years investigations on the ecology of the common shore crab, *Carcinus maenas*, have been carried out in inshore Danish waters (the Isefjord area, Zealand) and among other things the migrations of the species were studied. In contrast to the observations from British waters of Williamson[1] and others, it was observed that during the breeding season —which in the Isefjord comprises only May and June —the berried female crabs leave the littoral areas and hide in the more saline and deeper water (maximum depth 8–10 metres) until the larvæ are hatched. After this period they return to moult and copulate with the male crabs which stay all summer in shallow water (0–1·5 metres). The annual mean salinity of the Isefjord is 19·4 per mille.

It has now been found that sacculinized crabs (that is, both male and female crabs subjected to parasitic castration by *Sacculina*) carrying an externa (containing the gonads of the parasite) behave just like the normal berried females, that is, they hide in deep water. This seems to be normal for 'externa crabs' in the Isefjord, since it was found every year during the investigation from its start in 1954. It should be emphasized that the externa stage in the Isefjord normally appears in summer and is sexually ripe in the autumn. The observations are based on material comprising many hundred infested shore crabs.

As the early stage of parasitization is visible externally only in male crabs owing to the more-or-less pronounced parasitic feminization of the male phenotype, only males have been used in the following. For practical reasons the cycle of the parasite is here divided into five stages of development (Fig. 1): (*a*) crabs containing the interna stage only, noticeable by the feminization; (*b*) crabs with the externa just developed, 2–4 mm. broad; (*c*) crabs with an externa of medium size, 5–10 mm.; (*d*) crabs with sexually ripe externa, 11–20 mm.; and (*e*) crabs showing the hole after losing the externa; infection probably stopped. As seen in Fig. 1 only stages (*a*) and (*e*), namely, crabs exhibiting the beginning and the final phase of the parasite, are common in shallow water. The tendency of the 'externa crabs' to avoid the shore areas seems to be intensified with the ripening of the externa. Catches with traps in deeper water have confirmed this picture and shown the presence there of a rather high percentage of infested crabs with externa. It must be borne in mind, however, that the duration of the stay of the 'externa crabs' in deep water considerably exceeds that of the normal berried females, sometimes amounting to about a year or even more. This means that while the stages (*a*) to (*d*) of Fig. 1 represent the parasite in crabs one year old (infested in the autumn just after their metamorphosis in 1953), the final stage (*e*) of the parasite is present in crabs metamorphosed before 1953.

Broekhuysen[2] found that normal berried female crabs often show a characteristic behaviour of "egg cleaning and airing", consisting of piercing of the egg-mass by the pereiopods, followed by periodical flapping of the abdomen. A completely similar behaviour has now been observed in infested crabs of both sexes provided with an externa. In several cases studied in aquaria these characteristic movements were observed as soon as the externa appeared, and they seem to be intimately connected with the presence of an externa. In male crabs of maximal size and without any visible feminization at all the behaviour was also observable when the small externa broke through. This behaviour was shown to be highly affected by the oxygen tension of the water, low oxygen tensions accelerating the characteristic movements in a most conspicuous way.

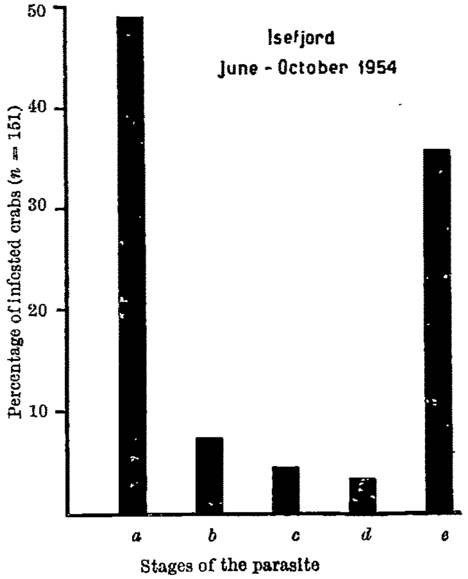

Fig. 1

The influence on behaviour caused by the disappearance of the externa shown by the field investigations was confirmed by observations in aquaria. In some cases where the externa had stopped producing its sexual products, and a slight decaying of the externa had begun, the behaviour mentioned above disappeared, and in several cases the host crab even tore the externa, and in one case was seen to be eating the remnants of the externa.

These observations suggest that only a living externa is able to promote the special behaviour seen in sacculinized crabs. It cannot, therefore, be regarded as a simple tactile response to the presence of a foreign object under the abdomen. I have made a few preliminary experiments with artificial externae fastened to the abdomen, and, though still inconclusive, they point in the same direction.

Without entering into a discussion of the various theories of the influence of the Rhizocephalous parasite on the host, I think that the behaviour of the parasitized crabs reported here may probably be interpreted as being due to a hormonal feminizing effect of the externa stage.

ERIK RASMUSSEN

Zoological Laboratory,
Royal Veterinary and Agricultural College,
Copenhagen.

---

[1] Williamson, H. Ch., Rep. Fish Board Scotl., **21**, iii (1903).

[2] Broekhuysen, G. J., *Arch. Neerland. de Zool.*, **2** (1937).

Histolytic Activity in Seasonal Hypertrophy of the Reproductive Organs of *Hyla aurea*

WHILE not yet reported in other frogs or in *Hyla aurea* elsewhere, hernia occurs in 0·3 per cent of this species taken in the Wellington district. The hernias seen involve various portions of the reproductive system, and are related to seasonal prebreeding organ hypertrophy. In one specimen, the uterine portion of the oviduct was ruptured through the body wall between the lateral face of the ilium and the origin of m. gluteus, to form a large mass in the dorsal lymph space. This appeared to be hernia by dissection along an anatomical pathway by pressure atrophy, as also in a second example where part of the testicular fat-body ruptured into the dorsal lymph-space between the body-wall muscles and the muscles on the lateral aspect of the ilium. A portion of the posterior lobe of the right ovary in another frog had perforated the mm. abdominis transversus and obliquus internus. This also was interpreted as based on pressure atrophy[1].

Establishment of a pathway by pressure atrophy was quite impossible in a case where an abnormally enlarged, elongated process of the right fat-body in a female had perforated the linea alba and formed a hernial mass in the ventral subcutaneous lymph-space shortly posterior to the xiphisternum. There is an absence of adhesions. It is beyond probability that a fat-body freely suspended from the dorsal aspect of the abdominal cavity could have induced atrophy by pressure in a structure such as the linea alba. Sudden mechanical pressure, such as a blow, a preformed embryonic pathway, failure of body-wall structure through postural gravity effects, interference with the vascular supply and other recognized causes of rupture likewise provided no satisfactory explanation for this case. Accordingly, it was suggested by way of hypothesis[2] that at the surface of a rapidly growing fat-body there are the mechanism of hyperplasia and hypertrophy and also a histolytic mechanism. The latter process, if induced by a substance transferable from the tip of the fat-body to the peritoneum and tissues of the linea alba, would provide a probable explanation for the establishment of the initial pathway for the hernia.

A further example in which the posterior lobe of the left ovary of a gravid adult frog extended into the left paravesical space, and, without adhesions, passed through the walls of the bladder to enter the right paravesical space and then the right femoral lymph-space where it expanded to normal size, gives further support to the above suggestion, especially since the foramen in the bladder is only 3·0 mm. in diameter, thus indicating that the bladder was perforated originally by the tip of the lobe of the ovary. The two walls of the bladder are fused around the margin of the perforation, and the lumen of the bladder closed off from the coelom. The posterior lobe of the right ovary had also ruptured into the femoral lymph-space, probably following the path established by the lobe of the left ovary.

The existence in the tadpole of histolytic processes is recognized in the tissue reductions and modifications during metamorphosis, and in the seasonal reduction of the reproductive organs following breeding. The results above indicate that a histolytic process is present during the growth and elaboration of the reproductive organs prior to breeding. It may be suggested that this process is responsible during that time for the breakdown of tissues which might otherwise cause mechanical difficulties during hyperplasia and hypertrophy of the adipose tissue in the fat-body and of the germinal tissue in the ovary. It may also assist in ovulation.

L. R. RICHARDSON

Department of Zoology,
Victoria University of Wellington,
New Zealand.
Nov. 21.

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A Monogenetic Trematode New to the British Fauna

IN the course of a survey of the parasite fauna of gadoid fishes in the northern North Sea, I have examined 28 cod (*Gadus callarias* L.) from various localities along the east coast of Scotland in the second half of 1958. The fish were all less than one year old and ranged in size from 12·4 to 18·6 cm. Three of these fish were infested by a species of *Gyrodactylus* (Trematoda: Monogenea), not hitherto recorded from British waters. The parasites were attached to the gills (rakers, bars and filaments) and within the buccal cavity of their hosts. One cod was found to harbour five specimens of *Gyrodactylus* in its nostrils—a somewhat unusual habitat for this trematode genus. The numbers of parasites varied from host to host, the lowest being 6 and the highest 197 specimens. All three infested fish were caught relatively near the shore: one was taken in the Firth of Forth, 5 miles east of May Island, and two about 15 miles south-east of Stonehaven, at a depth between 55 and 68 m.

The parasites were identified by Dr. Göran Malmberg of Zootomiska Institutet, Stockholm, as *Gyrodactylus callariatis*[1]. The species was described by Dr. Malmberg from cod taken in Nämdö, near Stockholm. The dimensions of the fresh specimens are as follow:

Total length	0·42–0·70 mm.
Body width	0·09–0·18 mm.
Opisthaptor length	0·08–0·12 mm.
Opisthaptor width	0·11–0·15 mm.

The anchoring apparatus of the species is distinguished by a dorsal bar with a central process pointing posteriorly. Its ventral bar is large and provided with wide antero-lateral processes. The membrane of the ventral bar is grooved and wide at the base. The marginal hooks are long and slender.

G. callariatis differs significantly from *G. marinus*, another species of the genus found on cod in the Barents Sea and the northern Pacific[2].

The genus *Gyrodactylus* contains relatively few marine species. They infest mainly young fish in coastal areas. Like some other monogenetic trematodes, *G. callariatis* appears to be a 'childhood' parasite[3], which might be the reason why it has not so far been discovered in British waters. Young stages of fish are only infrequently used for parasitological examinations.

I have also found another species of *Gyrodactylus* on whiting, *Gadus merlangus* L., in the same area. The specimens of this parasite are at present in Dr. Malmberg's hands.

Z. KABATA

Marine Laboratory,
Scottish Home Department,
Aberdeen.
Dec. 4.

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A Diagnostic Reaction of *Desulphovibrio desulphuricans*

THE sulphate-reducing bacteria at present available in pure culture are *Desulphovibrio desulphuricans*, its *aestuarii* variant[1], the thermophilic *Clostridium nigrificans* (earlier known as *D. thermodesulphuricans*[2]) and the new species *D. orientis*[3]. The species *D. rubentschickii* and its variant *anomalous*, able to utilize acetate and/or butyrate[4], have so far defied re-isolation.

Cl. nigrificans is readily distinguished from the other species by its thermophilic habit. *D. orientis* shows broad differences in appearance and motility from the *desulphuricans* pair, but is mainly distinguished by its multiple flagellation and ability occasionally to form spores, and neither of these features is technically very satisfactory for rapid diagnosis. A third distinguishing test has been devised making use of the absence of desulphoviridin[5] from *D. orientis*. The pigment desulphoviridin dissociates in alkaline solution to yield a photosensitive chromophoric group having a strong red fluorescence in ultra-violet light at 365 mμ.

The following procedure distinguishes pure cultures of *D. desulphuricans* and its *aestuarii* variant from *D. orientis*: a fully grown culture in 10 ml. of medium *C* of Butlin, Adams and Thomas[6] was centrifuged and the cells resuspended in 1 ml. water (final cell density 1·5–3 mgm. dry wt./ml.). One drop of 20 per cent sodium hydroxide was added and the suspension inspected at once in light at 365 mμ. Twenty strains of the *desulphuricans* group were tested and showed a brilliant red fluorescence; three strains of *D. orientis* did not, nor did six strains of *Cl. nigrificans*. Large amounts of ferric sulphide in the culture interfere, but may be removed by coarse filtration.

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JOHN POSTGATE

National Chemical Laboratory,
Teddington,
Middlesex.
Dec. 12.

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Separation of Specific and Non-Specific Effects of Chemicals on Plants

In working with the effects of chemicals on plants, it is often difficult to determine which of the effects obtained is specific to the chemical applied. For example, 2,4-dichlorophenoxyacetic acid (2,4-D) has been shown to cause numerous effects on plants. A recent review by Woodford *et al.*[1] discusses this subject in detail. It has been shown that 2,4-dichlorophenoxyacetic acid causes varied tissue changes, affects phosphorus metabolism, increases respiration, decreases photosynthesis and, in general, affects a great many functions of the plant.

Although it is true that these effects do occur on plants, it is by no means certain which, if any, of these reactions is of primary importance, and which are secondary. The living plant represents a dynamic, balanced system, and any change which affects one function of the plant will necessarily affect a great many others. Some of these changes will be associated with any type of killing mechanism; others will be specific. The data presented in many of the reports in the literature are not sufficient to establish this point. Frequently, there is no mention of whether there has been gross damage to the experimental plants, and the reader may suspect that the changes reported are simply those characteristic of damaged or dying plants.

One way of tackling the problem of which changes are of a non-specific nature is to use a control which has been allowed to die without outside chemical influence. We have attempted to do this in our experiment by digging up some of the plants, washing off the roots, and letting them lie on the greenhouse bench for the duration of the experiment. A similar technique was used by Loustalot *et al.*[2] in field experiments.

Bean plants (*Phaseolus vulgaris* L.) were grown in the greenhouse in a mixture of sand and peat soil until they were three weeks old. The beans were then selected for uniformity and treated. Foliage sprays of 1, 2, and 4 lb. per acre acid-equivalent of 2,4-dichlorophenoxyacetic acid (amine salt in water solution) were applied. There were four replicates of each treatment, and the plots were completely randomized in the greenhouse. The roots were harvested 1, 4, 11 and 18 days after treatment. Epinastic responses in the young leaves were visible on the first day after all treatments. The plants were dead in the 4 lb. treatment in 18 days. At this time, plants treated with 2 lb./acre were very stunted and malformed and those treated with 1 lb./acre apparently were recovering. Total protein content (alcohol-insoluble nitrogen) free amino-acid nitrogen, and individual amino-acids were determined as reported elsewhere[3,4]. A brief summary of the results is given in Tables 1 and 2. The trends for individual amino-acids were similar to those for total free amino-nitrogen. A fuller account of these results is in preparation.

Table 1. CHANGES OF PROTEIN IN TREATED BEAN ROOTS (MGM. ALCOHOL INSOLUBLE NITROGEN PER PLANT)

2,4-D per acre (lb.)	Days after treatment 1	4	18
0 (untreated)	2·64	2·54	2·80
1	2·90	2·58	2·51
2	2·71	—	1·60
4	2·51	2·30	1·30
0 (uprooted)	2·58	1·92	1·91

Table 2. CHANGES IN FREE AMINO NITROGEN IN TREATED BEAN ROOTS (MGM. PER PLANT)

2,4-D per acre (lb.)	Days after treatment 1	4	18
0 (untreated)	0·109	0·073	0·075
1	0·111	0·104	0·057
2	0·095	—	0·039
4	0·102	0·077	0·029
0 (uprooted)	0·114	0·090	0·006

Although pronounced changes occurred in the proteins of the plants following 2,4-dichlorophenoxyacetic acid treatment, and these changes appeared superficially to be correlated with the amount of 2,4-dichlorophenoxyacetic acid applied, it is obvious that equally drastic changes occurred in the plants that were uprooted and not treated with 2,4-dichlorophenoxyacetic acid. It appears, therefore, that these changes in the proteins and the amino-acids occurred as a result of damage or death, and not directly as a result of 2,4-dichlorophenoxyacetic acid treatment *per se*. Our results suggest, therefore, that the effect of 2,4-dichlorophenoxyacetic acid on protein metabolism is of secondary importance. They also emphasize the value of this type of control. Without this control, it would have been possible to draw exactly opposite and erroneous conclusions.

T. J. MUZIK

Department of Agronomy,
Washington State College,
Pullman, Washington.

J. M. LAWRENCE

Department of Agricultural Chemistry,
Washington State College,
Pullman, Washington.

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Effect of Boron Supply on the Sugars, Soluble in 80 per cent Ethanol, in Flax Seedlings

FLAX plants (*Linum usitatissimum* var. Ventnor) were grown in nutrient cultures supplied with increasing concentrations of boron. The methods were such that an addition of 0·001 p.p.m. boron to the basal medium produced a large growth response. After four weeks the plants were harvested and weighed (Fig. 1). The 0 p.p.m. boron plants grew very little throughout the four weeks; both these and the 0·001 p.p.m. boron plants showed typical deficiency symptoms in stems and roots.

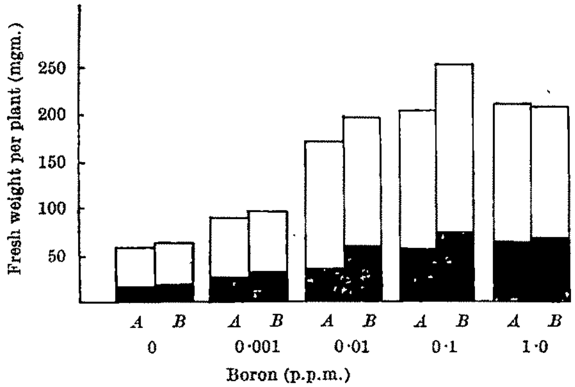

Fig. 1. Fresh weight of flax plants grown at increasing levels of boron supply. White, tops; black, roots

The plants of each treatment (which was duplicated) were divided into stem tips, the remainder of stem and leaves, and roots. These tissues were extracted with 85 per cent ethanol. Extracts, usually each equivalent to 40 mgm. fresh weight, were spotted on to No. 3 Whatman paper, and the chromatograms were eluted with a pyridine/ethyl acetate/water (80 : 20 : 10). Two chromatograms were run for each set of extracts. One was developed with silver nitrate and ethanolic sodium hydroxide; from the other the portions of paper corresponding to the sucrose, glucose and fructose spots were eluted and the sugars estimated by the method of Wager[1].

Sucrose, glucose and fructose were the principal sugars detected. Qualitative examination of the chromatogram (Fig. 2) showed no evidence that the stem tips and roots of boron-deficient plants were carbohydrate-deficient. The results of the quantitative analyses confirm this (Table 1).

Table 1. THE EFFECT OF BORON ON THE DISTRIBUTION OF SUGARS IN FLAX

P.p.m. boron in culture medium		0*	0·001*	0·01	0·1	1·0
		Sugar concentration (mgm./gm. fresh weight)				
Stem tips	Sucrose	0·90	1·85	2·18	2·00	1·57
	Glucose	3·00	2·90	1·55	1·10	1·14
	Fructose	1·98	2·48	0·67	0·32	0·39
Remainder of stem and leaves	Sucrose	0·41	0·13	0·37	0·41	0·38
	Glucose	1·75	1·40	0·73	1·40	1·00
	Fructose	1·00	0·85	0·79	0·73	0·30
Roots	Sucrose	None detected				
	Glucose	1·60	1·41	0·95	0·60	0·61
	Fructose	1·54	1·18	0·57	0·54	0·19

* Plants showing boron-deficiency symptoms.

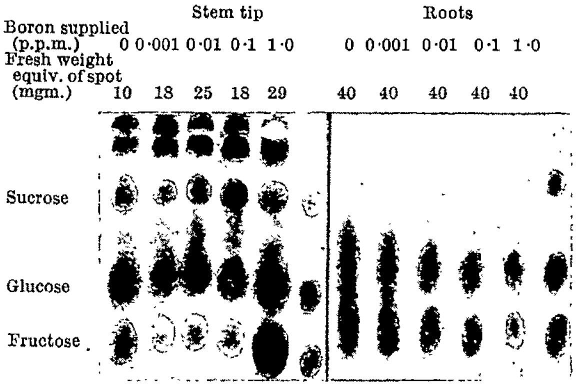

Fig. 2. The sugars in the stem tips and roots of flax plants grown at increasing levels of boron supply

Boron deficiency appears to depress the sucrose, but not the fructose or glucose content of flax stem tips. The remainder of the stems and leaves of boron-deficient plants in general contain more of the three sugars, expressed on the fresh weight basis, than normal plants, while in flax roots boron deficiency results in the accumulation of glucose and fructose.

These results do not support the hypothesis[2,3] that the cessation of growth in boron-deficient plants may be attributed to a carbohydrate deficiency in shoot tips and roots. It has further been demonstrated in this laboratory that excised flax roots grown in a specially purified sterile medium, which included 4 per cent sucrose, ceased to grow after 48 hr. in the absence of boron.

I wish to thank Dr. K. S. Rowan for advice on matters of technique.

T. F. NEALES

Botany School,
University of Melbourne,
Victoria, Australia.
Nov. 21.

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GEOLOGY and PHYSIOGRAPHY

Trap-Shotten Rock from the Biligirirangan Hills, Mysore State, India

CHARNOCKITIC rocks have been developed over a wide area in the southern part of the State of Mysore in India. The typical charnockites are found in isolated patches of varying dimensions. The largest of these occurrences is in the Biligirirangan Hills, where a fairly continuous mass of charnockite extending more than 25 miles forms this mountainous tract which lies between 11° 40′ and 12° N. In this region peaks of more than 5,000 ft. are common on the ranges, which generally trend in a north to south direction.

For the purposes of this communication, it is not necessary to describe the petrography or the rock associations of this interesting area. Attention is directed only to the fact that this elevated region, which is composed of charnockites, rises abruptly from the Mysore plateau of Peninsular gneisses, the demarcation being an almost straight line running north–south which corresponds roughly to longitude 77° 10′ E. This junction is characterized by a zone of trap-shotten material, which when examined under the microscope is seen to contain beautiful rosettes and radiating, parallel, or matted aggregates of microlites and skeleton crystals.

The trap-shotten rock is composed of a brown matrix with abundant minute specks of iron ore, in which fragments of charnockite as well as porphyroclasts of feldspar, quartz, and hypersthene are found. The quartzes are optically strained and often granulated. In the case of the plagioclases, the twin lamellæ are generally bent and sometimes obliterated. The borders of these xenoclasts are corroded and frequently embayed.

There is no glass at present, but the brown matrix shows signs of patchy devitrification being full of microlites of some mineral (? orthorhombic pyroxene) which are arranged as in a comb with parallel bars developed on either side of the central axis.

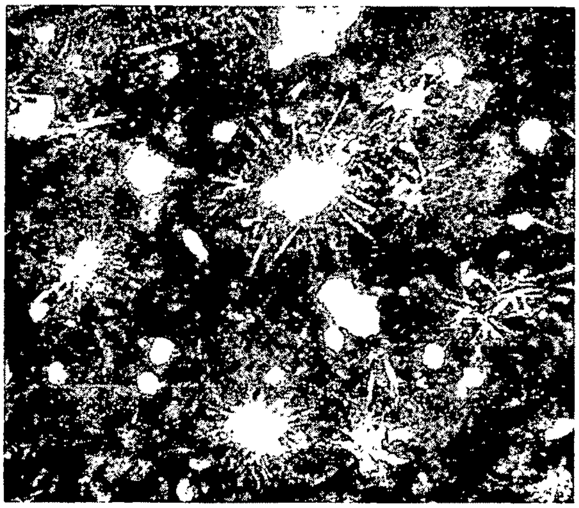

Fig. 1. Stellate aggregates of oligoclase in trap-shotten rock. The embayed quartz porphyroclasts do not serve as nuclei for the outgrowths of skeleton crystals. (× 40)

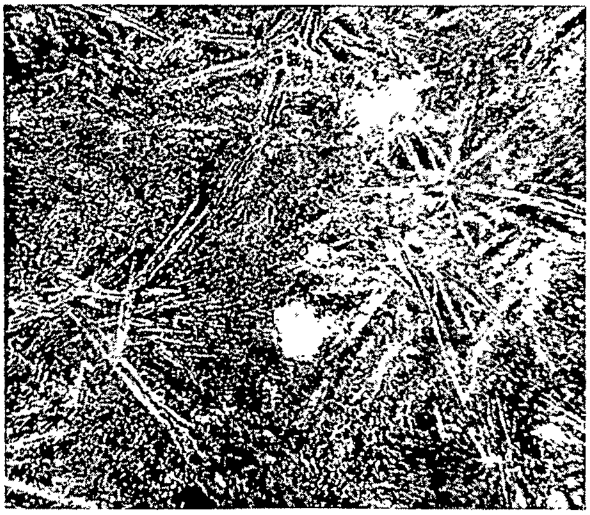

Fig. 2. Skeleton crystals of oligoclase in a devitrified irresolvable matrix. (× 160)

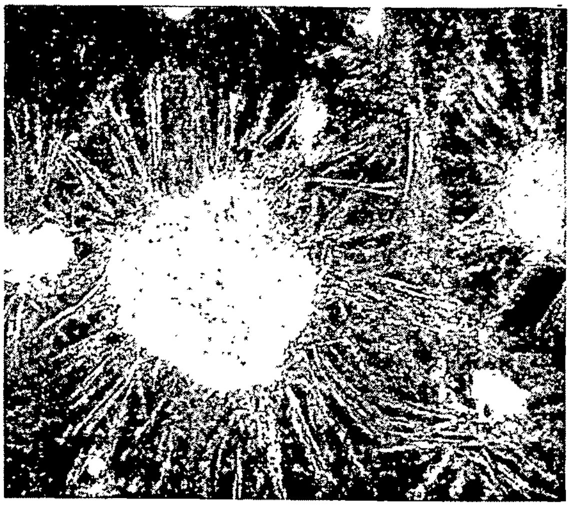

Fig. 3. Skeleton crystals of oligoclase radiating from plagioclase porphyroclasts. (× 120)

The junction between the pseudotachylyte and the country rock is quite sharp, the border being darker than the brownish interior. In some places it has penetrated into the charnockitic rock or engulfed fragments near the contact.

The most interesting feature of the pseudotachylyte is the occurrence of numerous star-shaped aggregates of skeleton crystals of feldspar (Fig. 1). The individuals are long and ladder-like, generally hollow and swallow-tailed (Fig. 2). They are also arranged in radiating patterns around porphyroclasts of plagioclase (Fig. 3). It is significant that the quartz fragments do not serve as nuclei for these outgrowths.

The extinction angle of these crystals is nearly straight, and the refractive index slightly higher than that of Canada balsam. These correspond to the characters of an oligoclase of composition about $Ab_{75}An_{25}$.

The temperature at which rocks can be fused by frictional heat has often been discussed. Shand[1], in his classification of pseudotachylytes, has listed Indian localities under "black rocks composed of crushed material without recrystallization or any evidence of elevated temperature", and doubtfully under "black rocks which bore evidence of high temperature approaching the melting points of some of the constituents, and with beginnings of crystallization". This is probably because of Holland's observation[2] that "the black material has essentially the microscopic structure of an indurated dust, never that of a rock cooled from fusion".

The example of trap-shotten rock from Mysore State described in this communication indicates that the temperature produced by friction was high enough to melt and cause the recrystallization of oligoclase in radiating aggregates.

C. S. PICHAMUTHU

Department of Geology,
University of Malaya,
Singapore 10.
Dec. 15.

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Heavy Minerals in Certain Old Red Sandstone and Silurian Limestones of Monmouth

THE Wenlock Limestone outcrops intermittently within the inlier of Silurian rocks situated between Usk and Pontypool, and the 'Cornstones'[1] as discontinuous bands within the Old Red Sandstone of Monmouth. Samples of both limestones were crushed, dispersed, and particles with a diameter greater than 0·2 mm. removed by wet sieving, and those with a diameter less than 0·02 mm. by decantation. The residue corresponding to fine sand contains the bulk of the heavy minerals which were separated in bromoform, identified, and their relative proportions determined by microscopic counts which have been combined in Table 1.

Table 1

	Old Red Sandstone Cornstones (per cent)	Silurian Wenlock Limestone (per cent)
Zircon	56	47
Tourmaline	13	15
Rutile	11	16
Garnet	7	11
Monazite	0	6
Epidote	3	5
Enstatite	4	0
Hypersthene	2	0
Fluorite	3	0
Anatase	1	0

Prismatic zircon grains with rounded terminations constitute the bulk of the heavy mineral assemblage in both limestones, mostly of dusky hue in the Wenlock Limestone and colourless within the Cornstones. Zircons within the latter show greater variety, some showing marked red staining and containing many inclusions which, in a few grains, are sufficiently abundant to render the grain almost opaque. Pink and pleochroic brown zircons may also occur. Tourmaline prisms with rounded rhombohedral terminations, pleochroic in all shades from green to brown, are moderately abundant in both limestones. The Cornstones contain, in addition, some well-worn rounded flakes. Also moderately abundant in both limestones are rutile grains, chiefly amber, which may be prismatic with rounded or irregular terminations or of a well-rolled character. A few grains in the Wenlock Limestone are foxy-red and in the Cornstones grey. Garnets, wine-red in colour and with pitted surfaces and polygonal outline, are more numerous within the Wenlock Limestone than in the Cornstones, where most garnets are colourless, contain many inclusions, and display an intricate rectangular outline presumably due to the dodecahedral cleavage.

Some yellowish, egg-shaped grains of monazite occur only in the Wenlock Limestone. Epidote prisms with rounded or irregular terminations are mostly of the orthorhombic zoisite variety in the Wenlock Limestone and monoclinic clinozoisite variety in the Cornstones. A very few grains of yellow anatase and fluorite occur only within the Cornstones. A characteristic feature of this limestone is the presence of pyroxene, either as dusky enstatite prisms or as pleochroic green and pinkish hypersthene prisms. One grain, too altered to allow accurate identification, may possibly be augite.

Slightly pleochroic, angular, green plates of chlorite are reasonably abundant in both limestones, and may be somewhat corroded at the margins within the Cornstones. Biotite is relatively uncommon. The opaque iron oxides are very abundant in both limestones, chiefly in the form of hæmatite in the Cornstones and both hæmatite and limonite in the Wenlock Limestone, with ilmenite of lesser quantitative importance in either case. Detrital quartz showing pronounced undulose extinction and streams of inclusions is also abundant. The feldspars consist chiefly of moderately fresh oligoclase, andesine and orthoclase. Anorthite grains are also quite numerous in the Cornstones. All the minerals show at least slight evidence of abrasion and are therefore detrital in origin.

The Wenlock Limestone is inter-stratified with argillaceous rocks which are more characteristic of relatively deeper depositional waters. The Cornstones are interbedded with marls and arenaceous rocks the presence of which suggests shallower water conditions, Heard and Davies suggesting brackish water lagoons with rapidly changing conditions. The slightly greater variety of mineral species within the assemblage of the Cornstones is consistent with a shallower water depositional environment. The mineral assemblage of the latter limestone shows an expected close similarity with that of the other Old Red Sandstone strata described by Heard and Davies. There is, however, the exceptional occurrence of pyroxene in the Cornstones. This mineral, less stable than other species such as zircon, rutile and tourmaline, appears to have been preserved within the limestone. This feature of the preservation of certain less stable mineral species in limestone interbedded with sandstones and shales has been noticed by Smithson in the Jurassic rocks of Yorkshire[2].

C. B. CRAMPTON

Soil Survey of England and Wales,
Rothamsted Experimental Station,
Harpenden,
Herts.

Jan. 6.

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Stability of Stone Polygons in North Wales

THIS communication describes certain preliminary observations made on stone polygons in Snowdonia during the summer of 1957, observations which appear to reveal the impermanent character of these structures. The polygon area has been briefly described by Pearsall[1]; it consists of several connected flat expanses of bare detritus, formed from the erosion of the Juncetum squarrosi occupying the broad ridge between Carnedd Llywelyn and Foel Grach summits in the Carneddau at 915–945 m. The area was casually examined several times during the summer of 1956, but no polygons were observed, the detritus being unsorted. In the course of field work during the first week of July 1957 well-defined stone polygons were noticed over the whole area (Fig. 1); each polygon was 45–60 cm. in diameter, with a centre of fine gravelly detritus and a rim, 10–15 cm. wide, of coarse stone (3–10 cm.); these coarse stones extended downwards for 10–15 cm., finally merging into a matrix continuous with the polygon centres. Ten days later, after predominantly fine weather but with a few days of rain with a blustery north-east wind, it was noticed that a large proportion of the polygons had, by apparent obliteration of the cross-connexions, been converted into stone stripes 2–4 m. long, orientated more or less at right angles to the direction of the prevailing wind (Fig. 2). For much of the remainder of July 1957 the weather was wet, with more or less permanent low cloud. On July 15 there was little change in the polygons. On July 30, however, after a fortnight of heavy rain and strong winds, a large number of the polygons and stripes had been obliterated or were in process of obliteration. On September 3 one of the areas was almost completely unsorted, and many of the stripes on the other areas were indistinct. Polygons were very rare, and the stripes had markedly elongated, extending for many metres without interruption. In July 1958, the next opportunity for a further examination, the area exhibited little change, except qualitatively in that the stone stripes appeared far less elongated.

It has been supposed that the balance between polygons and stripes is determined by slope, polygons being developed only on flat ground, elongated polygons on ground with a slope of 2–7 deg., and stripes on ground with a slope of 10 deg. or more[2]. On the area described above there is an imperceptible slope, of 1–1·5 deg. east–west, down which the stripes are orientated, but the occurrence of polygons among the stripes cannot be related to any localized flat areas. It is interesting to note that patches within the polygon area with a developing plant cover (of *Rhacomitrium lanuginosum*) have completely unsorted detritus, suggesting a recent origin for the polygons, and that areas with partly obliterated polygons are characteristically flat.

It has only recently been realized how rapid the processes of change in stone polygon and stripe areas can be. Undoubtedly many of these structures are exceedingly stable: thus photographs of polygons in the French Alps taken in 1934, 1942 and 1947 superposed exactly[2]. On the other hand, Michaud and Cailleux destroyed stone stripes in the same region in August 1947, and they had been reformed in August 1949 continuous with the undisturbed stripes[3]. The same authors marked stones in six polygons, and after two years there had been appreciable change in two of them: the stones had moved up to 10 cm. on the surface, and some of them were found buried at a depth of 13 cm. Cailleux and Taylor[2] also record polygons and stripes formed on moraines abandoned four years previously.

Thus the observations in North Wales are not unique, though the rapidity of change appears unparalleled. The winter of 1956–57 in North Wales was marked by intense cold with only minimal snow cover—ideal conditions for polygon formation (since a covering of snow reduces the depth of penetration of frost into the soil by some 2–2½ times, and delays thawing by the same factor). In normal winters the ridge between Carnedd Llywelyn and Foel Grach has a good depth of snow. The rapid changes during July 1957 appear to be related to the unusually heavy rainfall and high winds; the polygon area has a high water-table, and after heavy rain this may locally reach the surface. On July 30, 1957, the mean depth of the water-table below the polygons was 10–12 cm., but a few were still saturated throughout. It may be that during heavy rain the finer detritus becomes almost liquid and flows among the intervening larger stones, while under the influence of strong winds there may be considerable movement of these larger stones also. The observations suggest that on an area with a slope barely sufficient for 'elongated polygon' formation, cryoturbatic processes may result in the formation of more or less isodiametric polygons, but that afterwards rain and wind may accentuate the effect of the slope and result in a transformation into elongated polygons. The extremely potent erosive action of wind-driven rain at high altitudes is testified in the vegetation throughout North Wales, and the combination of relatively mild winters, high rainfall, and frequent strong winds must certainly be inimical to the continued survival of any polygon and stripe systems.

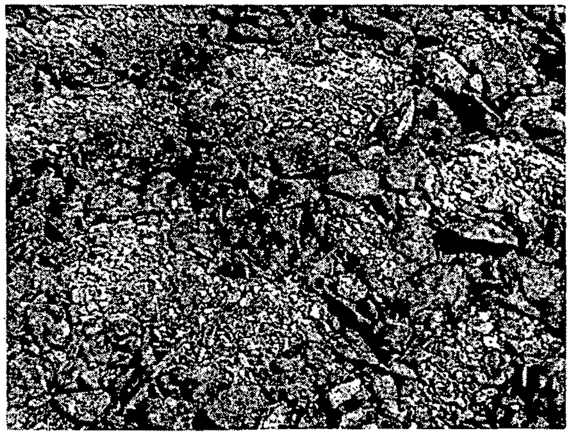

Fig. 1. Detail of stone polygons, July 2, 1957

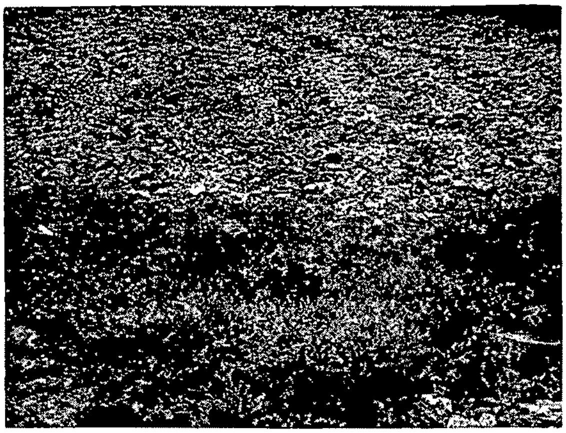

Fig. 2. General view of elongated polygons, July 15, 1957

These observations are necessarily incomplete, since the desirability of a more quantitative approach was not realized until too late, but it is believed that they are of sufficient interest to merit recording in this incomplete form.

JOHN H. TALLIS

Department of Botany,
University College of North Wales,
Aberystwyth.

K. A. KERSHAW

Department of Botany,
Imperial College of Science and Technology,
London, S.W.7.

Dec. 10.

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[1] Pearsall, W. H., "Mountains and Moorlands" (Collins, 1950).

[2] Cailleux, A., and Taylor, G., "Actualités scientifiques et industrielles 1203. Expéditions Polaires françaises IV. Cryopédologie, études des sols gelées" (Hermann et Cie., Paris, 1954).

[3] Michaud, J., and Cailleux, A., *C.R. Acad. Sci., Paris*, **230**, 814 (1950).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, February 16

Society of Chemical Industry (joint meeting of the Surface Activity Group and the Pesticides Group, at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. G. S. Hartley: "The Role of Surface Active Substances in the Application of Pesticides".

University of London Institute of Education (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Prof. E. A. Peel: "Behaviourism and Verbal Learning".*

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Group-Captain D. St. C. Smallwood, O.B.E.: "Mongolia, 1958".

Monday, February 16—Tuesday, February 17

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2)—Specialist Discussion Meetings on "New Digital-Computer Techniques".

Tuesday, February 17

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. A. D. Blest: "The Evolutionary Origins of Distance Communication by Honey-Bees".*

Institution of British Agricultural Engineers (at 6 Buckingham Gate, London, S.W.1), at 2.15 p.m.—Mr. P. G. Finn-Kelcey: "The Application of Electricity to Agriculture".

London School of Economics and Political Science (at Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Dr. G. Tugendhat: "The Economics of Energy".* (Further lectures on February 23 and March 3.)

Institution of Mechanical Engineers, Hydraulics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Pumping of Liquids of Unusual Viscosity, Volatility, or Solid or Gas Content".

British Computer Society (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. R. Neate: "The Simulation of Melting Shop Operations on a Computer".

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Dr. A. W. C. Taylor: "Sources of Raw Materials for the Plastics Industry".

Society of Chemical Industry, London Section (at the Royal Empire Society, Northumberland Avenue, London, W.C.2), at 6.30 p.m.—Film Evening.

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. R. H. Woodall: "Engine Starting Systems".

Wednesday, February 18

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. E. G. Richardson: "Rheology—the Science of Plastic Flow".

Physical Society, Colour Group (in the Small Physics Theatre, Imperial College, Imperial Institute Road, London, S.W.7), at 3.30 p.m.—Miss J. Cox: "Colour Vision Defects acquired in Diseases of the Eye"; Mr. M. Clowes: "Colour and the Stabilized Retinal Image"; Mr. I. M. Gibson: "Visual Mechanisms in a Cone Monochromat".

Eugenics Society (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Dr. Mary Stocks: "Reflexions on a Changing Class Structure"* (Galton Lecture).

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. J. S. Sawyer: "The Temperature, Humidity and Cloud Near Fronts in the Middle and Upper Troposphere"; Mr. F. K. Ball: "Long Waves, Lee Waves and Gravity Waves"; Mr. B. J. Mason and Mr. J. Maybank: "Ice-Nucleating Properties of Some Natural Mineral Dusts".

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. P. Armitage: "The Comparison of Survival Curves".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. N. Smyth and Mr. J. Sayers: "Ultrasonic Iconoscopes".

Royal Institute of Chemistry, London Section (at King's College, Strand, London, W.C.2), at 6.30 p.m.—Dr. F. E. T. Kingman: "Chemical Aspects of Fire Prevention".

Thursday, February 19

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Owen Wansbrough-Jones, K.B.E., C.B.: "Some Chemical Advances in the Ministry of Supply".

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. S. Webb and Dr. J. S. Tooms: "Geochemical Drainage Reconnaissance for Copper in Northern Rhodesia".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. F. Wilkinson: "Rounding Errors in Algebraic Processes".

Royal Aeronautical Society (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. E. G. C. Burt: "Theoretical Studies of Guided Missile Systems".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. S. H. Bell: "Paint and Paint Films as Chemical and Physical Structures".

Institution of Mechanical Engineers, Graduate's Section (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.30 p.m.—Mr. T. N. Dewey and Mr. J. E. Stephenson: "Gyroscopes in Automatic Controls".

Institute of Biology, London Branch (at 41 Queen's Gate, London, S.W.7), at 7.30 p.m.—Dr. C. G. Butler: "The Social Organization of the Honey Bee Community".*

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Prof. K. R. Hill: "Some Aspects of Liver Disease in the West Indies".

Friday, February 20

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. D. McNaughton: "Meteorological Briefing Information".

Institution of Electrical Engineers, Radio and Measurement Sections (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. V. J. Terry and Mr. E. P. G. Wright: "The Measurement of Errors in Data Transmission for the Design of Detecting and Correcting Equipment".

University of London (at Senate House, London, W.C.1), at 5.30 p.m.—Prof. K. Skovgaard (Copenhagen): "The Pattern of an Unsubsidized Agriculture".*

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. L. E. Culver and Prof. Hugh Ford: "Experimental Study of Some Variables of the Tube Expanding Process".

Society for Analytical Chemistry, Microchemistry Group (at the School of Pharmacy, 29–30 Brunswick Square, London, W.C.1), at 6.45 p.m.—Annual General Meeting. 7 p.m.—Mr. D. F. Phillips: retiring Chairman's Address.

Association of Clinical Biochemists (in the Clinical Lecture Theatre, The Middlesex Hospital, Mortimer Street, London, W.1), at 7 p.m.—Prof. C. Rimington, F.R.S.: "Porphyria".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. B. C. Browne: "The Earth's Gravitational Field".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Manager (with an honours degree in physics or equivalent, wide research and development experience, and the ability to direct a large team of scientists) at the Research and Development Laboratories, Windscale, to direct teams engaged on research and development work for Calder Hall and for advanced designs of gas-cooled reactors—Chief Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2911/J.15 (February 23).

Assistant Lecturer (with experience in experimental physics, aeronomy or astronomy) in Applied Mathematics (Geophysical)—The Secretary, The Queen's University, Belfast (February 25).

Scientific Officer (with a first- or second-class honours degree in physics, chemistry or engineering) at the Fire Research Station (D.S.I.R.), Boreham Wood, Herts, for work on the growth and spread of fire and associated combustion and fluid flow problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.312/8A (February 27).

Assistant Experimental Officer, for work with an electron microscope in the Plant Pathology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (February 28).

Assistant Experimental Officer (male) at Dunholme Field Station, Lincoln, to work on sugar beet pests—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (February 28).

Assistant (science graduate, preferably with qualifications in physiology or biochemistry, or both) in Clinical Chemistry—The Secretary, The University, Aberdeen (February 28).

Chair of Zoology and Comparative Anatomy—The Registrar, Trinity College, Dublin (February 28).

Chemist (male, with a degree in chemistry or equivalent qualification, and preferably experience in analysis) in the Plant Protective Chemistry Section, to assist in studies of insecticides and fungicides on fruit plants—The Secretary, East Malling Research Station, near Maidstone, Kent (February 28).

Demonstrators in the Department of Physics—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (February 28).

Imperial Chemical Industries Research Fellows in Chemistry, Engineering or Physics—The Registrar, Trinity College, Dublin (February 28).

Lecturer in Applied Mathematics (Digital Computing)—The Secretary, The Queen's University, Belfast (February 28).

Lecturer in Mathematics, and a Lecturer in Physics at Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (February 28).

Head (with a good honours degree in chemistry or a related science, with at least a registrable qualification in pharmacy, and preferably teaching or additional practical experience in some branch of pharmacy) of the New Zealand School of Pharmacy, Central Technical College, Petone—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. B.11/8/5 and mentioning *Nature* (March 1).

Reader in Applied Mathematics or in Mathematical Statistics—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (March 2).

Lecturer in Pure Mathematics, and a Lecturer in Applied Mathematics—The Secretary, The University, 38 North Bailey, Durham (March 4).

Lecturer (with special interests in one or more of the following: climatology, geomorphology, soil science) in Geography—The Secretary, The University, 38 North Bailey, Durham (March 4).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Engineering and Physics—The Secretary and Registrar, The University, Southampton (March 7).

Lecturer or Assistant Lecturer in Applied Mathematics—The Registrar, The University, Hull (March 7).

Lecturers or Assistant Lecturers in Geography at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 15).

Research Fellow in Organic Chemistry, for work on natural products under the direction of Prof. R. A. Raphael—The Secretary of University Court, The University, Glasgow, W.2 (March 16).

Research Fellows (2) in the Department of Nuclear Physics, Research School of Physical Sciences, Australian National University, to work either in the field of nuclear spectroscopy or on photonuclear problems—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 16).

Assistant Lecturer in Mathematics—The Registrar, University College of Wales, Aberystwyth (March 19).

Veterinary Research Officer or Scientific Officer (with a degree in science, agricultural science or veterinary science, with postgraduate experience in entomology, preferably with reference to ecto-parasitology) at Wallaceville Animal Research Station, New Zealand, to specialize in ecto-parasitology research work of farm animals—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. B.11/2/14 and mentioning *Nature* (March 20).

Lecturers (2) (with interests in inorganic or physical chemistry) in Chemistry at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 21).

Assistant Lecturer (with special qualifications in petrology) in Geology—The Secretary, The Queen's University, Belfast (March 31).

Imperial Chemical Industries Research Fellows in Chemistry or Physics—The Registrar, The University, Hull (March 31).

Professor of Geology and Mineralogy at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Queensland, Brisbane, Queensland, Australia (March 31).

Research Student (with a good honours degree in zoology, or good prospects of obtaining such) in the Department of Zoology, for work in river ecology—The Secretary, The University, Exeter (April 4).

Lecturers (2) in Botany—The Secretary, The Queen's University, Belfast (April 10).

Forest Utilization Officer (with an honours degree in forestry, physics or biology, able to initiate forest products research work, and preferably postgraduate experience in research and timber utilization) in Northern Rhodesia, for research work covering a wide range of forest products but primarily to improve utilization of *Brachystegia* timbers in underground conditions in the copper mines—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/3/02.

Junior and Senior Fellows (with at least 2 or 3 years postgraduate experience), for research in Chemistry, Physics, Mathematical Physics, Metallurgy, Chemical Engineering, Biochemistry and Food Technology—The Graduate Recruitment Officer (1344/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Laboratory Technician (male, with experience in rock sectioning, etc., photography and general laboratory maintenance)—The Secretary, The University, Exeter.

Librarian (woman, preferably with a medical or scientific background), for small medical and scientific library—Ciba Foundation, 41 Portland Place, London, W.1.

Physicist (with a good honours degree) in the Middlesex Hospital Medical School Physics Department, for duties concerned mainly with radiotherapy physics—The Secretary, Barnato Joel Laboratories, Middlesex Hospital, London, W.1.

Reader in Mechanical Engineering, and a Reader in Electrical Engineering—The Registrar, Bradford Institute of Technology, Bradford 7.

Research Assistant (honours graduate in botany, agricultural botany or agriculture (crop husbandry)) in Potato Agronomy in the Department of Agriculture—The Secretary, School of Agriculture (University of Nottingham), Sutton Bonnington, Loughborough, Leics.

Senior Lecturer (with a high qualification in chemistry, together with experience of chemical plant, or a qualification in chemical engineering and appropriate experience) in Chemical Technology, and a Senior Lecturer (with a high academic qualification together with research experience) in Chemistry—The Principal, Welsh College of Advanced Technology, Cathays Park, Cardiff.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories on Industrial Health for the year 1957. Pp. 50. (Cmnd. 553.) (London: H.M. Stationery Office, 1958.) 3*s*. net.* [1612

European Brewery Convention. Report of the Barley Committee, Trials 1957. Pp. 138. (London: Institute of Brewing, 1958.) [1612

Proceedings of the University of Durham Philosophical Society. Vol. 13, Series A (Science). No. 6: The Age and Origin of the Hemiptera with special reference to the Sub-order Homoptera. Part 2: The Assessment, Integration, and Use of the Evidence from Fossil and Modern Homoptera in Phylogenetic Deduction. By G. Heslop-Harrison. Pp. 41–53. No. 7: Stress Relaxation in False-Bodied Suspensions. By R. Roscoe. Pp. 54–58. No. 8: On the Origin and Function of the Pupal Stadia in Holometanolous Insecta. By G. Heslop-Harrison. Pp. 59–79. No. 9: Botanical Investigations in the Isles of Lewis, Harris and Great Bernera (v.–c.110) and in the Isle of Rhum (v.–c. 104) in 1957. By J. W. Heslop-Harrison. Pp. 80–88. Vol. 1, Series B (Arts). No. 3: Types and Tokens in Language. By Barbara M. H. Strang. Pp. 17–25. (Durham: University of Durham Philosophical Society, 1958.) [1612

Stewarts and Lloyds, Ltd. Leo: a Computer in the Service of the Steel Industry. Pp. 20. Department of Research and Technical Development. Pp. 24. (Corby: Stewart and Lloyds, Ltd., 1958.) [1612

National Institute of Industrial Psychology. Report No. 13: Comments on the Job: Views of Employees in Six Companies. By Isabel Blain. Pp. iv+20. (London: National Institute of Industrial Psychology, 1958.) [1612

British Rayon Research Association. Eleventh Annual Report, October 1958. Report of the Directors of Research for 1957–1958. Pp. 30. (Manchester: British Rayon Research Association, 1958.) [1612

Ciba (A.R.L.) Limited. Technical Notes, No. 191 (November 1958): Manufacture of 'Weyroc' Chipboard. Pp. 10. (Duxford: Ciba (A.R.L.), Ltd., 1958.) [1612

The Registrar General's Statistical Review of England and Wales for the year 1957. Part 1: Tables, Medical. Pp. x+373. (London: H.M. Stationery Office, 1958.) 20*s*. net. [1612

Department of Scientific and Industrial Research. Graduates in British Industry. (The main findings of a Study by P.E.P.) Pp. iv+28. (London: Department of Scientific and Industrial Research, 1958.) [1612

Other Countries

Somaliland Protectorate. Annual Report of the Geological Survey Department for period April 1957—March 1958. Pp. ii+18. (Hargeisa, Somaliland: Geological Survey; London: Crown Agents for Oversea Governments and Administrations, 1958.) 2*s*. [1612

University of California Publications in Botany. Vol. 30, No. 1: Umbelliferae of Japan. By Minosuke Hiroe and Lincoln Constance. Pp. 1–144 (75 figures). (Berkeley and Los Angeles: University of California Press, 1958.) 2.75 dollars. [1612

Government of India: Central Board of Geophysics. Publication No. 4: Proceedings of the Symposium on Ground Water, 1955. Pp. xvi+400. (Calcutta: Central Board of Geophysics, 1958.) [1612

National Research Council of Canada. Report on University Support for Science, Engineering and Medicine for the 42nd Year of Operation, 1958–59. Pp. ii+143. (Ottawa: National Research Council, 1958.) 50 cents. [1612

Annals of the New York Academy of Sciences. Vol. 71, Article 6: Genetic Concept for the Origin of Cancer. By L. C. Strong and 28 other authors. Pp. 807–1241. 5 dollars. Vol. 72, Article 9: Lymphocytes and Plasmacytes in Nucleoprotein Metabolism. By Margaret A. Kelsall and Edward D. Crabb. Pp. 293–338. 2 dollars. Vol. 72, Article 11: Rational Simplifications for the Buckling Length of Columns. By Thomas C. Kavanagh. Pp. 353–386. 2.50 dollars. Vol. 73, Article 1: Hodgkin's Disease. By Antonio Rottino and 33 other authors. Pp. 1–380. 4.50 dollars. Vol. 73, Article 2: Surgical Convalescence. By F. Curtiss Dohan and 19 other authors. Pp. 381–538. 4 dollars. Vol. 73, Article 3: Third Tissue Homotransplantation Conference. By John M. Converse, Blair O. Rogers and 75 other authors. Pp. 539–868. 5 dollars. Vol. 74, Article 1: Contributions of the Physical, Biological and Psychological Sciences in Human Disability. By Renato Contini, Sidney Fishman and 18 other authors. Pp. 1–160. 3.50 dollars. Vol. 75, Article 1: Enzymes in Blood. By Laurens P. White and 81 other authors. Pp. 1–384. 5 dollars. Vol. 76, Article 2: The Basic and Clinical Research of the New Antibiotic, Kanamycin. By Maxwell Finland and 93 other authors. Pp. 17–408. 5 dollars. (New York: New York Academy of Sciences, 1958.) [1612

State of Illinois: Department of Registration and Education. Natural History Survey Division. Biological Notes No. 38: Ectoparasites of the Cottontail Rabbit in Lee County, Northern Illinois. By Lewis J. Stannard, Jr., and L. R. Pietsch. Pp. 18. Biological Notes No. 39: A Guide to Ageing in Pheasant Embryos. By Ronald F. Labisky. Pp. 5. (Urbana, Ill.: Illinois Natural History Survey, 1958.) [1612

California Legislature. Assembly Interim Committee Reports, Vol. 5, No. 5: An Annotated Bibliography of Research in Economically Important Species of California Fish and Game. Compiled by William F. Schuermann, Jr. Pp. 271. (Sacramento, Calif.: Assembly of the State of California, Room 3111, State Capitol Annexe, 1958.) [1612

Companhia de Diamantes de Angola (Diamang). Servicos Culturais. Dundo—Lunda—Angola. Museu do Dundo. Subsidios para o Estudo da Biologia na Lunda. Publicacoes Culturais No. 39: Tenebrionidae of Angola. By C. Koch. Pp. 231+43 plates. (Lisboa: Companhia de Diamantes de Angola, 1958.) [1612

University of Natal. Report for 1957–58 (Eleventh Year) of the Wattle Research Institute, (South African Wattle Growers' Union—University of Natal—Union Department of Forestry.) Pp. 40. (Pietermaritzburg: Wattle Research Institute, University of Natal: 1958.) [1612

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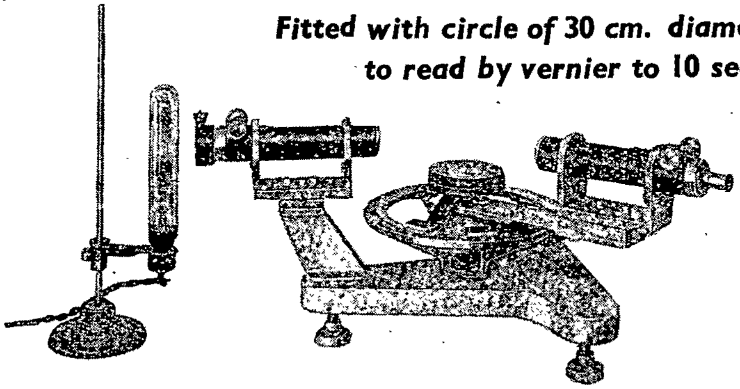

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SCIENTIFIC AND TECHNOLOGICAL MAN-POWER

A COMPARATIVE study of scientific man-power in the public service of Great Britain and selected European countries, including Denmark, France, Germany, the Netherlands, Norway, the U.S.S.R., Sweden and Switzerland, was undertaken by Mr. E. McCrensky[*] primarily to throw light on the management of scientific man-power in the United States. It provides, however, much more than an appropriate background to the survey of the problem of scientific man-power as it presents itself in the United States made by Mr. D. C. Greenwood[†]. Its chapters on the higher education of engineers and its survey of the organization for research in various countries bring to light factors that tend to be overlooked and are highly pertinent to the expansion of technological education in progress in Great Britain, particularly at a time when the structure of the national research organization, and especially that administered by the Department of Scientific and Industrial Research, is under criticism.

The early chapters of Mr. McCrensky's book survey the position and work of scientists in Government service, the methods of attracting to, and retaining, scientists in such careers, the payment for professional public services and the representation of scientists; and in the final chapter he summarizes the administrative methods and training practices he has observed and emphasizes particularly the features which could be applied elsewhere. Much of the material he has collected has not hitherto been published, and it is notable how well British practice stands out in comparison with that elsewhere. Indeed, it would seem that in some respects the Scientific Civil Service in Britain is far ahead of other Western countries and the United States, and that most countries have scarcely grasped the importance of the principles laid down in the Barlow report on scientific staff fifteen years ago for the effective use of scientific man-power.

As Sir Harry Melville points out in a foreword, the problems of handling scientists tend to become similar wherever they are studied, and although the book is concerned primarily with the use of scientists in the service of the State, the problems that arise are interlocked with the conditions that exist elsewhere—in industry, in the public corporations and in the universities. Differentials in salary arrangements and policies, in the opportunities and freedom to organize research work, to discuss scientific problems and the professional encouragement which is given, all play their part in attracting men and women from one sphere to another and in holding them there; and conditions of service in general must be considered in relation to the conditions and opportunities available to the scientist both in his own country and abroad. Apart from this, Mr. McCrensky recognizes the importance both of wise and sympathetic management and the bearing of favourable working conditions on effective scientific activity as on other creative work.

This survey of Mr. McCrensky's firmly dispels the idea that the scientist should be merely 'on tap' and not, where he possesses the requisite administrative ability, 'on top'. Mr. McCrensky recognizes, indeed, the difficulty of securing the essential flexibility and of deciding at what point in a scientific career to encourage positively the development of some understanding of the principles of administration, management policies and skill in handling people; but he believes that the British Civil Service is in the vanguard, not only of the countries of Western Europe but also of the United States, in its concrete attempt to meet this need. He points, as example, to the residential conferences run by the Treasury, lasting about eight days, and attended by about twenty senior scientists, engineers, architects and administrators, selected from different fields so as to secure the maximum of cross-fertilization of ideas.

Effective communication is undoubtedly a key factor in the management of scientists and securing effective co-operation, as indeed the experience of operational research during the Second World War indicates; and the encouragement in such ways of clearer and more personal understanding of the distribution of responsibilities in government could also help to stimulate the readiness of scientists to share such responsibilities and fit them for such posts. Moreover, even more important, it could help to balance that inherent difficulty in recruitment for government service, in which, in contrast to industry, the same fixed salary is offered to the marginal as to the brilliant candidate. Here again the British Scientific Civil Service at its higher levels is regarded as more sensitive to the special needs of those engaged in creative scientific research than those of any other country of Western Europe, and reference is made particularly to the composition of the Civil Service Commission and to the Interdepartmental Scientific Panel, and to the consistent and uniform application of the principle that scientists and their work can only be properly and acceptably evaluated by their peers.

Nevertheless, Mr. McCrensky makes some criticisms. The rate of promotion in Britain is slower than in the United States, although comparing favourably with most West European countries. The stratification among the three classes in the Scientific Civil Service is sharply defined, reflecting to some extent the national education system. Mobility is also limited by the rigid maximum age limit for entry into the scientific officer class, which normally debars individuals more than thirty-one years of age from competing for permanent posts in the Government service. Finally, some stress is laid on the disparity between the salary scales for the highest positions in the scientific class and those in the administrative class.

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[*] Scientific Manpower in Europe: a Comparative Study of Scientific Manpower in the Public Service of Great Britain and selected European Countries. By Edward McCrensky. Pp. ix+188. (London and New York: Pergamon Press, 1958.) 40*s*. net.

[†] Solving the Scientist Shortage. By David C. Greenwood. Pp. viii+68. (Washington, D.C.: Public Affairs Press, 1958.) 2 dollars.

These criticisms are relevant in considering the expansion of university and technological education in Britain, for they indicate weaknesses which could well be accentuated as expansion proceeds and even partly frustrate its very purpose. European experience generally confirms the importance of leaving the selection and promotion of scientists so far as possible in their own professional hands within the public service, and affording the broadest possible latitude of self-determination of their administrative responsibilities. Again, the status and prestige of scientific organizations in the public service are enhanced and sustained by the continuous contact of their staff with scientists of the highest standing in other sectors of national life, and Mr. McCrensky instances the value of the National Research Committee in France and its participation in the National Scientific Research Centre. France, as well as Norway and Denmark, uses long-term contracts to provide a higher salary-range in compensation for typical service rights and benefits; but the permanence of tenure conferred by a permanent appointment is a distinguishing characteristic of the systems described in this book. The British Scientific Civil Service certainly demonstrates the practicability of pursuing a life-time career in government service under conditions which do not discourage creative scientific work; but the survey points to the need for strong personal leadership at the highest level if a Government personnel system is to meet the needs of scientists and engineers, as well as for the support of representative leading scientists.

As regards payment for professional public service, Mr. McCrensky's survey suggests that generally Civil services need to establish efficient and reliable internal means for collecting and evaluating current information on prevailing salaries for reasonably comparable positions elsewhere as a basis for a sound policy. Modification of national systems based on a rigid complement of positions within each grade is regarded as offering a major opportunity of improvement, and in this connexion he cites the system followed in the Netherlands by the Central Organization for Applied Research and the 'merit' type of promotions used in the British Scientific Civil Service. The contract type of employment used for engineers in Denmark could also be used more frequently, and provision of a differential of pay allowances and additional leave to the higher levels also merit consideration. Sometimes the necessary flexibility in establishing salaries for scientists and engineers can only be gained by separating government scientific activities from the Civil service, as has been done to some extent in Denmark for engineers, for applied research in the Netherlands and for basic and applied research in the National Scientific Research Centre in France.

The establishment of an independent panel of distinguished citizens to advise the government on its pay policy is also suggested as a constructive measure; but it is not clear what advantage this step would offer over the existing interdepartmental scientific panel in Britain. Part of the problem for the scientist is to translate his views and needs into terms of government administration, and this is unlikely to be done better by those who are not his professional colleagues. This is the key problem in the representation of scientists, and Mr. McCrensky thinks that the attention which has been given to it in Britain in the structure of the Civil Service Commission and the Panel is a distinctive mark of the British system and one that is conspicuously missing from other Civil service systems. He notes, however, that the influence of the Commission is limited to recruitment, and that it has little authority for subsequent leadership. Largely, however, this seems again to be a problem in communication, for in modern governments heads of departments and ministries seem to be precluded by their broad scope of functions and responsibilities from understanding precisely the needs and points of view of the scientist or technologist.

Here, accordingly, the problem is linked up with that of education, for clearly it is necessary to-day that those entering on administrative responsibilities should be equipped by training to have some understanding of at least the approach of the scientist or technologist. That is a condition of the efficient use of trained man-power, and in its absence we shall not make full use of the increasing numbers of scientists and technologists now coming from the universities and colleges of technology. Curiously enough, this point is overlooked by Mr. McCrensky, although in considering the higher education of engineers he notes as probably applicable elsewhere the incorporation of humanistic subjects in the curricula of the technological institutions at Delft and Zurich, and the Norwegian policy of training a proportion of engineers abroad as a progressive measure to broaden their cultural background.

It is such suggestions rather than specific recommendations that mark Mr. McCrensky's survey. He notes features that could be considered for adoption or adaptation, but is aware of the danger of attempting to transplant practice or policy from one country to another without regard to differences in traditions and conditions. Consistently, however, he found a wide gap between the identification and full knowledge of major problems in the efficient management of scientists in the public service, and the initiation of action required to alleviate or eliminate such problems.

Mr. Greenwood, in the second book referred to, attributes the shortage of trained man-power in the United States mainly to about a dozen factors, most of which operate also in Great Britain and other countries. The low birth-rate of the 1930's caused a decline in the enrolment in college in the early 1950's. The failure of many talented youths to complete their high school or college courses was due to various causes. Relatively long training periods, shortages of qualified teachers, inadequate facilities and equipment for research and training, current heavy demands for technologists and scientists and the failure of the educational system to anticipate the increasing demand for technologists all contributed to the shortage, as did predictions of a surplus of engineers, the periodical appearance of 'scare' articles, low salaries and the demand for, and response to, technical assistance abroad.

Mr. Greenwood's recommendations for solving the shortage follow surveys of the educational outlook in the United States, which have stressed the importance of not allowing the scale, quality, character and flexibility of American education to lag behind its increasing responsibilities, of the Government demands for scientific and technical man-power, and those of private industry and of professional programmes designed to deal with the situation. They fall into seven groups according to whether they are addressed to industry, to the Federal Government, to educational institutions, to chambers of commerce, to State Governments, to professional bodies or to the general community. Most of them fall into the first two groups ; but of those addressed to industry only about a fifth are concerned specifically with relieving the man-power shortage, the remainder being directed to raising professional standards or qualifications and increasing the efficiency with which scientific man-power is used.

Under the first heading fall recommendations for encouraging participation in professional activities, including the publication of technical papers and attendance at technical meetings and advanced courses. Under the second, besides more attention to providing appropriate conditions for professional work, relieving trained men and women of work which makes no demands on their professional competence is recommended, as well as providing full auxiliary facilities, and the recognition of competence above average. To relieve the shortage more specifically, Mr. Greenwood suggests full use of older scientific personnel of fifty or sixty, who have several years of useful and productive work ahead of them, and the use wherever practicable of skilled handicapped workers, as well as of qualified women. Trained man-power is also conserved considerably by improved methods of management, including the three-shift system to make maximum use of available equipment. Stress is again laid on the importance of an adequate number of technicians, and there should be no compulsory retiring age for engineers and scientists.

Among the recommendations addressed to the Federal Government, the simplification of the administration of secrecy clearance is strongly advocated, and the more realistic classification of secret material. Stress is laid on the translation of Russian technical literature and the value of greater interchange of allied scientists. But for the rest, the recommendations are directed towards providing a scientist as adviser in each Department of State in which science plays a part and ensuring that the use of scientists in work on defence is properly co-ordinated, overlapping eliminated and that scientists in the Armed Forces are used only on duties which demand their professional knowledge and qualifications. Those addressed to educational institutions contain a number which in Britain would properly be addressed to the Government, and it is interesting to note that while special attention to the brilliant and promising student is recommended, Mr. Greenwood also suggests discontinuance of the present practice of spending time and thought on the maladjusted at the expense of the brilliant child. No less forthright is his advocacy of eliminating courses of no real academic value before we produce a generation of well-adjusted ignoramuses—a warning it would be rash to regard as applying solely to the United States.

Other educational recommendations relate to the salaries of teachers, the maintenance of academic standards and the diversion to technical colleges or similar institutions of as many as possible of the 50 per cent of the engineering students in United States universities who at present fail to complete their courses. The suggestions addressed to professional associations appear to be comparatively minor, and urge closer liaison with the universities and colleges and steps to encourage interest in the schools in science and engineering as careers. Those for the general community note the importance of according scientists and technologists adequate status and recognition.

There is thus little that is new in Mr. Greenwood's recommendations, or that has not already been suggested in Britain in such reports as that of the Willis Jackson Committee or that on "Early Leaving". Surprisingly, comparatively little is said about expanding the output of scientists and technologists : the emphasis is all on eliminating the waste of trained man-power, whether by ensuring it is engaged on tasks that demand professional competence or by providing the conditions under which the scientist and technologist can work most effectively. There is likewise a definite emphasis on the early removal from higher educational institutions of students who seem unlikely to complete their courses, and to make the places available for more talented or satisfactory students as early as possible. The emphasis is all on encouraging ability, and especially outstanding ability, rather than bolstering up mediocrity.

There is, on the whole, a striking parallel between Mr. Greenwood's conclusions and the comments in the latest report of the Advisory Council on Scientific Policy on the scientific and engineering man-power situation in Britain. The key to the removal of the shortage remains the supply of teachers of science and mathematics, and no new suggestions are made for dealing with this situation. Both surveys, in fact, point to the imperative need of action here, and give the removal of the particular shortage of science teachers a priority and an urgency which is lacking in the latest White Paper on secondary education in Britain. Nevertheless, that White Paper does recognize the bearing of an adequate supply of technicians and craftsmen on the efficiency with which the nation is able to use its scientists and technologists. But both Mr. Greenwood's survey and that of Mr. McCrensky deserve to be studied by the Minister of Education and the Lord President of the Council, for they point unmistakably to the essential factors which will determine the success or failure of efforts in Britain to increase the supply of scientists and technologists to a level commensurate with the nation's needs, and to ensure that the maximum use is made of the men and women thus trained.

CONCEPTS OF NUCLEAR PHYSICS

Nuclear Structure

By Leonard Eisenbud and Prof. Eugene P. Wigner. (Investigations in Physics, Vol. 8.) Pp. viii + 128. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1958.) 25*s*. net.

THERE are surprisingly few up-to-date text-books of theoretical nuclear physics which may be recommended to the final-year honours student or to the postgraduate beginner. Many books have been written containing a wealth of detail both inessential and confusing to the beginner; several which treat particular topics at some length but fail to give any sense of balance; only one or two of the calibre of this one, and these are mostly out of date owing to the speed at which nuclear physics has grown. In the space of a little more than one hundred pages the authors present a clear and balanced account of the whole of low-energy nuclear physics. As one would expect of Prof. E. P. Wigner and Dr. L. Eisenbud, the book is entirely theoretical in its approach, although essentially non-mathematical. That is to say, the authors have dispensed with the usual long-winded accounts, so common in elementary text-books, of the process of acquiring the data on which the interpretation is based. There are some nuclear physicists who will frown at this even to-day: yet even they would not expect to describe the workings of an ammeter during a discourse on the conductivity of metals, or the properties of spectroscopes while expounding the electronic structure of atoms. The techniques of nuclear physics, both experimental and mathematical, can be found elsewhere: here one will find the concepts.

The first three chapters are descriptive, giving the general features of nuclei, their energy systematics and ground-state properties. As an illustration of how up to date the book is, one notes that the values quoted for nuclear radii are those recently obtained by Hofstadter using the scattering of high-energy electrons. The fourth chapter gives a correspondingly descriptive account of the various types of nuclear reactions. At the end of this chapter occurs about the only reference to practical matters, in the delightfully succinct sentence: "Nuclear reactions can be used to produce radioactive elements". The fifth chapter gives a brief account of the properties of the two-body system and of nuclear forces. Here again one finds a modern picture, with Levy's potential, complete with hard core, appearing in the most unembarrassing fashion. The three following chapters are concerned with the various models which have been put forward to try to understand nuclear properties. Only the essential assumptions and most significant results of each model are discussed, and the relations between them. There follow two chapters on the theory of nuclear reactions, the first of which gives a beautiful and almost painless account of the powerful *R*-matrix theory (or rather of its essential concepts, for it is only the details which are gruesome and these are omitted, in keeping with the rest of the book), the second an account of stripping reactions and Coulomb excitations. Resonance formulæ, reduced widths, radioactivity, complex potentials, giant resonances—they are all included within a very few pages, without fuss, and yet, somehow, with sufficient explanation to make one feel one really understands it all. The final two chapters deal with beta-decay and with electromagnetic transitions. Here, unfortunately, the book is already obsolete: scalar and tensor reign supreme and parity goes inviolate. A most valuable addition is the list of carefully selected references, which are commented upon by the authors so that an inexperienced reader can easily find his way to the vast modern literature.

The critical reader may certainly find some faults. There seem to be one or two misprints, and it is a pity that the word 'Fermi' has been introduced as a synonym for 'barn'. Although the usage is historically correct, the Fermi is now almost fully established as the nuclear unit of length. One may wonder why the *LS*- and *jj*-coupling models are presented in such contrasting tones: most people to-day would regard them as extremes of a very narrow band of colours. But these are quibbles. It is an excellent little book, warmly to be recommended to anyone who wishes to obtain an authoritative and balanced view of the concepts of nuclear physics. Even the price is a welcome surprise. B. H. FLOWERS

FLUID SYSTEMS IN CHEMICAL ENGINEERING

Chemical Engineering Practice

Edited by Herbert W. Cremer and Trefor Davies. Vol. 5: Fluid Systems I. Pp. vi + 695 + xxiv. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 95*s*.; 13.30 dollars.

THERE is probably no aspect of chemical engineering that has received greater attention, and which so clearly indicates the special nature of this technology, than that of distillation. In the petroleum industry the installed capacity for distillation is greater than that for any other operation, and the modern petrochemical industry as well as the conventional organic chemical industry are wide users of distillation equipment. A large section of this volume is taken up with an account of the techniques of, and equipment for, distillation, and for this reason alone this work will receive much attention. The allied operation of liquid – liquid extraction is also covered, so that we have here an exposition of two of the really important chemical engineering operations which have been widely developed by chemical engineers. There are other important sections which will prove of considerable value not only to the professional chemical engineer but also to that wider body of engineers whose work brings them to chemical engineering from time to time. The main topics discussed are transportation of liquids and gases, the design of high-pressure vessels, the production of vacuum, liquid – liquid stage-wise operation, and distillation.

In the first chapter, Hey gives a summary of the types of pump available for handling liquids, including an adequate account of their construction and maintenance, and a very useful note on methods of controlling flow. One might have expected something on the newer types, such as electromagnetics, and some greater detail on the important class of metering pumps.

The next section, on the transport of gases, by Messrs. Barrett, Jackson and Brown from Imperial Chemical Industries, Ltd., contains a most readable discussion on blowers, fans and compressors, and is improved by having two examples worked out. Williamson, also from Imperial Chemical Industries, Ltd., provides a really practical guide to the design of pipe systems, in which he has condensed much practical experience in a chapter on a topic not previously discussed in the literature.

The design of high-pressure equipment is covered by Prof. D. M. Newitt and Mr. K. E. Bett, of the Imperial College of Science and Technology, London. The difficulties of creep, of high temperature, of gaseous diffusion, and of embrittlement are well brought out and the various methods for design and construction are described. They give a large number of references which are helpful; but work in this field calls for specialization for the few, and this chapter serves rather to underline the problems as seen by chemical engineers than to provide detailed design solutions which are more properly the province of mechanical engineering. One would like to have seen something on the heavy cost per unit volume of reactors for very high pressures.

Section 5, by Barrett and Power, from the Edwards High Vacuum Company, provides a good account of the selection of equipment for this duty. While there is some repetition of earlier work on fluid friction, the real problems of flow at very low pressures are well explained with one or two illustrations.

Almost the whole of the second part of the book is devoted to the operations of liquid – liquid extraction and of distillation. Prof. F. H. Garner and his colleagues from Birmingham first describe the nature of the phase equilibrium in liquid – liquid systems both for ternary and multicomponent systems and then outline the calculations required to determine the number of stage-wise units required. The section on selectivity of the solvent is perhaps the most interesting, and the illustrations of the use of the triangular and rectangular co-ordinate diagrams will help many readers. The examples given here are both well chosen and well presented.

In a somewhat parallel chapter, Prof. S. R. M. Ellis describes the calculations of the stages required for a distillation operation. He gives all the normal methods and illustrates them with good examples. He has provided a useful analysis of the batch still, a subject too frequently neglected.

The section on equipment for both operations is by Dr. Freshwater, and, although he describes the problems of entrainment, capacity and pressure-drop, one is left a little wondering if it all fits together. One really good example from practice would have brought out the order of magnitude of the various terms and left a clearer idea of the operating conditions. The use of computers for the calculation of changes in composition in stills with multicomponent systems is not indicated, and little is said as to the range of temperature and pressure for which the design techniques are satisfactory. The problem of handling widely different ratios of liquids and gases is not emphasized.

This volume catches the spirit of chemical engineering; there is no doubt one is dealing with real chemical plant. This is a good text which will be used by many.

J. M. COULSON

INTELLIGENCE, FAMILY BACKGROUND AND EDUCATIONAL PROGRESS IN SCOTLAND

Eleven-Year-Olds Grow Up

By John S. Macpherson. (Publications of the Scottish Council for Research in Education, No. 42.) Pp. xxiii+184. (London: University of London Press, 1958.) 15s. net.

THE Scottish Council for Research in Education here presents the first report on the information it has been collecting since 1947 concerning the educational and vocational progress of some 2,000 children born in Scotland in 1936. This group of children is a representative sample of all those born in that year; it is, as the report suggests, a "Scotland in miniature", "ranging over the whole scale of intelligence, born in every month of the year, from different social classes, from Lowlands, Highlands and Islands, from village, city and town, from large families and small". The report describes what has happened to this Scottish sample between 1947, when the last mental survey of the whole age-group was undertaken, and 1954, by which time practically all had left school and chosen or embarked on their first occupation. Many matters of interest and importance are dealt with; the effect of parental ambitions and sex differences on occupational choice, relationships between the occupations of sons and fathers, change of occupations, the attitudes of young workers to further part-time education, the leisure interests of young people and the attitudes of boys to National Service.

The report hinges, however, on the examination of the relation between measured intelligence at the age of eleven, and the subsequent educational and vocational progress of the pupils in the sample. It is, in fact, a description in some detail of the process of educational and occupational selection in Scotland, as reflected in the experiences of the age-group of children who entered secondary schools two years after the Second World War. The two questions of interest are the value of measured intelligence at the age of eleven as a predicter of future academic and vocational achievement, and the possible biasing influence of extraneous social factors on the process of educational and occupational selection whereby talent should find its own level.

So far as the predictive value of measured intelligence is concerned, the report makes it clear that this is limited to estimating for a group of pupils the proportion likely to be successful in following a particular school course or class of occupation, but that it would be impossible to predict on this basis alone the individual pupils who would go to make up the successful group. However, one further piece of information about each child involved makes it possible to predict relative chances at least one degree more accurately, and that is the father's occupation.

Social factors are strongly at work in the process of educational selection. The report under review, like that of the Central Advisory Council for Education in England ("Early Leaving", H.M. Stationery Office; 1954), although in a technically more refined manner, shows a relationship in the selective secondary school between the father's occupational class and a child's chances of completing the course and proceeding to advanced work which is practically independent of intelligence quotient (*IQ*). Thus, in the Scottish sample, for able boys with an *IQ* greater than 120 coming from working-class families (namely, those whose fathers are manual workers) the chances of completing the course are about 2 in 5; but for similarly able boys from other (that is to say, non-manual) families, the chances are about 2 in 3. For those with an *IQ* less than 120 there is the same difference in chances according to social background; for working-class boys at this level of ability they are about 1 in 5, but for others 1 in 2. However, the Scottish report explores the implications of this striking finding much less thoroughly and imaginatively than the English report. Related findings, such as that early leavers tend to be deficient in personal qualities such as industry, or had very difficult home circumstances, or did not find the course interesting or useful for the career they had in mind, or were known not to be succeeding in the course for other known or unknown reasons, are accepted at their face-value as psychological irreducibles. The English report, on the other hand, examines the possibility that those factors are systematically related to sociological variables such as father's occupation, size and sex of the school, or the social and economic character of the neighbourhood in which it is situated. Clearly these are the lines, sociological rather than psychological, on which further work on the problems of educational selection and performance must proceed. JEAN FLOUD

CRITIQUE OF WITTGENSTEIN'S PHILOSOPHY

The Later Philosophy of Wittgenstein

A Short Introduction, with an Epilogue on John Wisdom. By Dr. David Pole. Pp. vi+132. (London: The Athlone Press, University of London, 1958. Distributed by Constable and Co., Ltd.) 15*s*. net.

IN this book, small in size but weighty in learning, Dr. D. Pole sets out to be an interpreter and, in part, critic of Wittgenstein's later thought as expressed in his posthumous writings. Appropriately enough, a chapter is included on the work of Prof. Wisdom, whose method is characteristically British, though he has done much to graft it on (and this is in itself no mean achievement) to the Germanic, and even Hegelian strain running through Wittgenstein.

These essays begin with a discussion of the linguistic approach to philosophy, followed by some detailed observations upon logic and normative language, together with the place of inner experience. The main theme is rounded off by a consideration of the difficulties in Wittgenstein's philosophy. In all this, one cannot be blind to the immense change which came over Wittgenstein since he first startled the learned world with the "Tractatus" in 1922.

A favourite illustration is that of a machine running idle, or of a wheel spinning freely without engaging with the rest of the machinery. Such a mental situation derives from forgetting that language is something which we inherit, whereas a calculus is a deliberate construct. Noteworthy, too, is the view that for Wittgenstein a mathematician is more an inventor than a discoverer.

Yet Wittgenstein, himself no professional mathematician, helped that discipline substantially in several ways, not least by the realization that "in working with shapes, we create our concepts".

Perhaps it is hereabouts that Wittgenstein makes an incidental contribution of importance to psychology in throwing up, as it were, the nature of boundaries as perceived in geometric figures. This is common ground for *Gestalt-theorie*, behaviourism, and even for parts of isomorphism. Some of these may be out of fashion but they are part of man's heritage, and Dr. Pole has done well to include hints of them in his valuable study. F. I. G. RAWLINS

THE CLERK IN INDUSTRY

The Blackcoated Worker

A Study in Class Consciousness. By David Lockwood. (Studies in Society.) Pp. 224. (London: George Allen and Unwin, Ltd., 1958.) 21*s*. net.

THE position of the clerk in industry and commerce has changed considerably during the past forty years. Before the First World War the clerk commanded authority and respect *vis-a-vis* the manual worker. Because of his closeness to the employer he was paid more, was treated as a person of considerable status both because of his knowledge of the company's secrets and because of his literacy, and often succeeded to posts of management responsibility because of his experience in administration. Now, as David Lockwood shows in a scholarly, well-planned and carefully written investigation, the clerk's position is generally very different.

In the days of the counting-house, clerks were nearly all male and were recruited from middle-class families, frequently from the homes of clerks themselves. To-day, much of the work in a mechanized office is done by females, many of whom—as well as their male counterparts—are recruited from the lower social strata. Up to 1914 the ordinary adult clerk earned roughly the same as a skilled manual worker. In 1958 even the aristocracy of blackcoated labour—the banking and insurance clerks—no longer enjoy an economic status clearly distinct from the wage-earning classes; the mass of clerks are roughly on the same income-level as the average manual worker. The clerk's position is also changing relative to that of the manual worker with regard both to job security and 'fringe' benefits.

These are some of the generalizations which emerge from factual information so painstakingly gathered and sifted by the author. They reinforce the experiences of all who are concerned with the place of the clerk in industry and commerce and should illuminate the implication of modern trends. Reduced pay differentials, greater job insecurity and the difficulty of finding other jobs when declared redundant, as well as lessened chances of promotion with the introduction of management trainees, are some of the factors combining to make the clerk's position more unstable. As a consequence, many firms are already finding it difficult to recruit sufficient clerks of the right quality. Lockwood's book should be read by all employers who are faced with this problem and are prepared to tackle it before it becomes too unwieldy.

A NEW SOLUTION TO THE ATLANTIC EEL PROBLEM

By Dr. DENYS W. TUCKER
British Museum (Natural History)

TWO nominal species of Atlantic eel (*Anguilla*) are currently recognized, mainly distinguished by their myomere/vertebra counts. *A. rostrata* (Le Sueur) of North America has 103–111 vertebræ (mode 107); *A. anguilla* L. of Europe and North Africa has 110–119 (mode 115). These two eels are more closely allied in every respect than either is to any other[1]; the remaining discriminating characters comprise small differences in mean numbers of branchiostegals (11·03 : 10·78), pectoral rays (16·73 : 17·37), etc., and minor differences of body-form of no greater importance than those formerly held to justify the recognition of a dozen European 'species'[2]. Both include 'long-nosed' and 'broad-nosed' varieties; both have a sexual disparity of size. Their larvæ "are outwardly so alike as to be hardly distinguishable"[3].

Two thousand years of speculation on the life-history of the European eel[2] culminated in the classic solution of Schmidt[3,4], a well-publicized saga which scarcely requires detailed repetition. Schmidt, sorting the *A. rostrata* and *A. anguilla* leptocephalus larvæ on their myomere counts, laboriously plotted the limits of distribution of larvæ of various lengths (Fig. 1) and so eventually traced their apparent origins to two supposedly distinct, though partially overlapping, areas in the region of the Sargasso Sea which were presumed to embrace the actual spawning-areas. The last was an assumption based on circumstantial evidence; eggs were never found, and, for those who disallow the careful claim of Fish[5], denied by Schmidt[6] and by Tåning[7], never have been. Furthermore, the *A. rostrata* prelarvæ have yet to be found; *Anguilla* adults have yet to be taken in the open ocean (one from the stomach of a cachalot off the Azores[8] is obviously suspect of local provenance); naturally ripe eels in full breeding-dress (as demonstrated by hormone-injection experiments[9]) have yet to be observed. However, Schmidt did demonstrate the fact of an oceanic spawning and show conclusively that the American eels complete their pelagic stages in one year, whereas the European ones require three years before they enter the inshore waters of their respective continents.

Schmidt's now generally accepted solution demands, not only a long journey on the part of the nearest

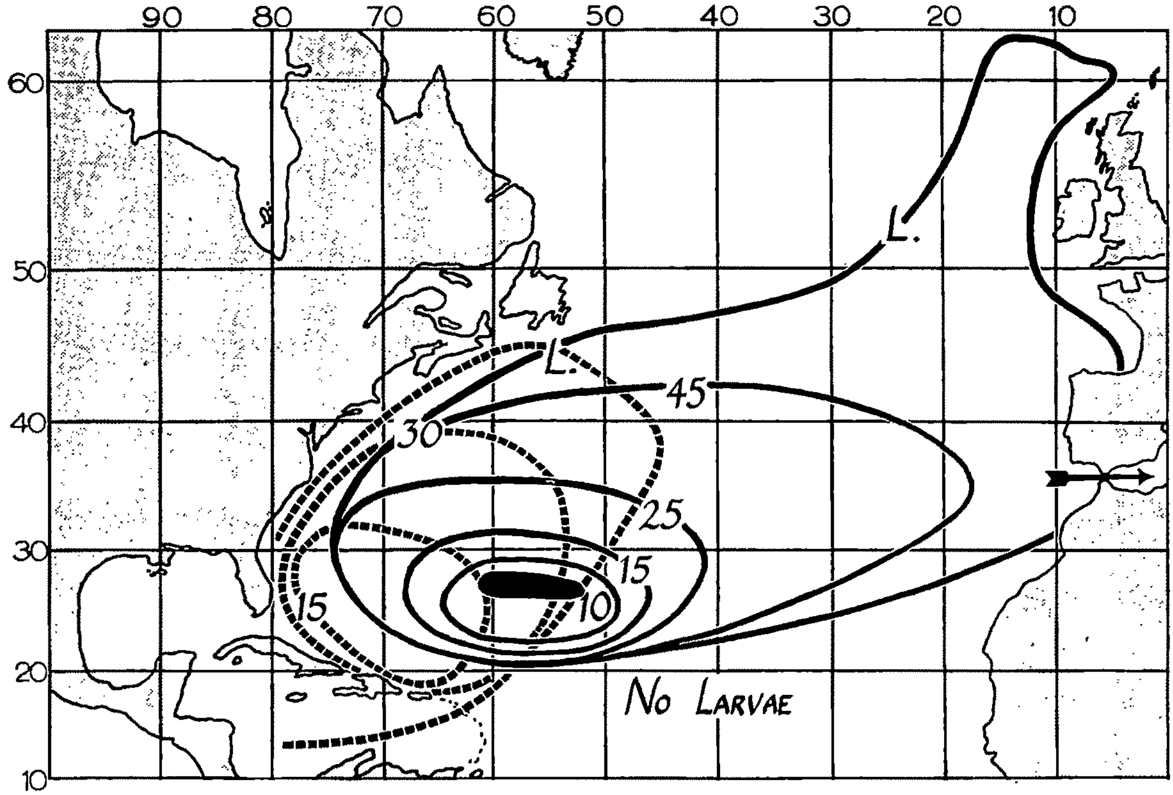

Fig. 1. Distribution of Atlantic *Anguilla* larvæ. ——, *A. anguilla*; – – –, *A. rostrata*. The curves show the limits of occurrence of larvæ of the indicated mm. lengths. The black area shows the distribution of newly hatched (5–7 mm.) *A. anguilla* prelarvæ. Curves *L* mark the limits for unmetamorphosed larvæ. (After Schmidt, refs. 3 and 4)

American eels returning to their spawning area, but a much longer one, of the order of at least 3,500 miles on a great circle course, by the European eels. The present article rejects the latter assumption and proposes a new and drastically different interpretation of the observed phenomena, namely :

(1) That the European eels need not and do not succeed in returning to the ancestral spawning-area, but perish in their own continental waters.

(2) That the American and European eels are not distinct species, but merely eco-phenotypes of *Anguilla anguilla*, their apparent distinguishing characters being environmentally determined (in the manner of numerous precedents) by demonstrable differences in temperature conditions encountered during the ascent from different parts of the American eels' spawning area to the surface, and their distribution by demonstrable coincident differences in the subsequent transport of the surface water-masses.

(3) That the populations of the so-called 'European' eels, *A. anguilla*, are therefore entirely maintained by reinforcements of larvæ of American '*A. rostrata*' parentage.

The evidence and arguments are presented under three broadly corresponding headings.

(1) Evidence against the Return of the European Eel to the Spawning Area

Differences between the morphological and physiological states of the European and American eels on their descent to the sea are remarkable in a context quite apart from taxonomy. The European eel is already well advanced towards being a reproductive oceanic fish, and this despite the long journey which supposedly lies before it. The American eel, with a much smaller distance/time to go, is yet relatively retarded. The two conditions are the reverse of what any reasonable consideration of adaptive characters and natural selection would predict.

The American eel[10], on average a larger and four times heavier fish than the European (females, 56 : 14 oz.), descends to the sea as a 'bronze' or 'black' eel, in a migration livery which is little more than a darkening of the normal colour accompanied by metallic reflexions. Fat has accumulated to about one-third of the total body-weight ; feeding has ceased and the gut begun to degenerate. The gonad has been scarcely studied, but there is certainly no enlargement of the eye, no change from the normal short, rounded form of the pectoral fin, no blocking of the vent nor any assumption of silver coloration[10]. Its condition thus approximates to that of the 'yellow' eel of Europe.

The European eel[2] descends as the well-known 'silver' eel, having a broad band of guanine running the length of its belly. Along with a profound degeneration of the gut and perceptible enlargement of the gonads, there is marked enlargement of the sense-organs ; the eyes, in particular, double their diameter[10,11], though without increasing the number of retinal elements[12] which were previously intensely crowded behind a contractile pupil[13]. The pectoral fin becomes lengthened, lanceolate and black[10,11]. One apparently normal (that is, non-pathological) fish from the North Sea showed complete occlusion of the vent[14]. In very few examples (*post*) has any more advanced gonadial condition been observed in Nature. We have, therefore, in the typical case, a fish degenerate and unable to feed, having a fat reserve which must provide for the maturation and vast enlargement of the gonads as well as for the propulsion of the enfeebled body on a presumed 3,500-mile journey. Instances of longevity in eels (fed or starved) in captivity[2,10,15] are irrelevant to this problem, since their normal physiological modification had, in every case, ceased or regressed after capture.

The European eel shows positive reactions to higher temperature and salinity ; negative ones to solid bodies and to light[2]. Agreed that all *A. anguilla* are derived by passive dispersal from one breeding area, there can be only one common inherited pattern of behaviour, yet this has hitherto been assumed adequate to direct the return journeys of eels leaving points all over Europe and North Africa and successfully traversing a great variety of conditions to a common oceanic terminal. Any lingering resistance to the new hypothesis may be dispelled by a study of Sverdrup *et al.*[16] considering, for example, the complexly involuted current/temperature/salinity conditions in the inner Mediterranean, the flow of Mediterranean water through the Atlantic, the north-going Norwegian Coastal Current which leaves the Baltic and heads for the Arctic, and the complicated counter-clockwise circulation of the North Sea. How could eels regularly negotiate such systems and end up in the western tropical Atlantic ? Furthermore, while theories demanding either passive transport by currents alone or active response to gradients alone are inadequate, since many of the currents are of the order of a mile a day and many of the gradients gradual over vast areas of ocean, theories involving both must, under European conditions, obviously contain a large degree of self-contradiction (Fig. 2). There can be only one inherited pattern of behaviour ; therefore, moreover, a hypothetical pattern of complicated and successive changes of behaviour which might take a Baltic eel via the Azores or via Jan Mayen to the Sargasso would serve no purpose to one leaving the Black Sea.

Marking experiments have proved the passage of eels along the Baltic[17] ; eels have been captured rarely at the mouth of the English Channel[18,19] ; the exodus has been observed at many points around the Mediterranean[20,21]. But these cases provide proof only of local short-range migrations. The eels, if they survived, would be abundant. Why have they never been taken by research vessels in the open Atlantic or by the intensive fisheries along the Continental Slope ? Are agility and this or that depth of swimming adequate explanations ? The expected passage of the vast Mediterranean populations through

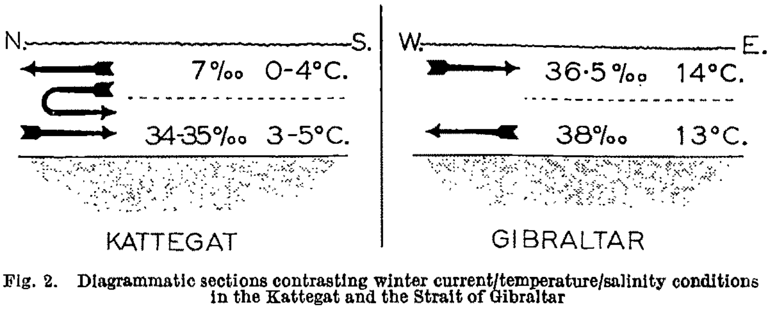

Fig. 2. Diagrammatic sections contrasting winter current/temperature/salinity conditions in the Kattegat and the Strait of Gibraltar

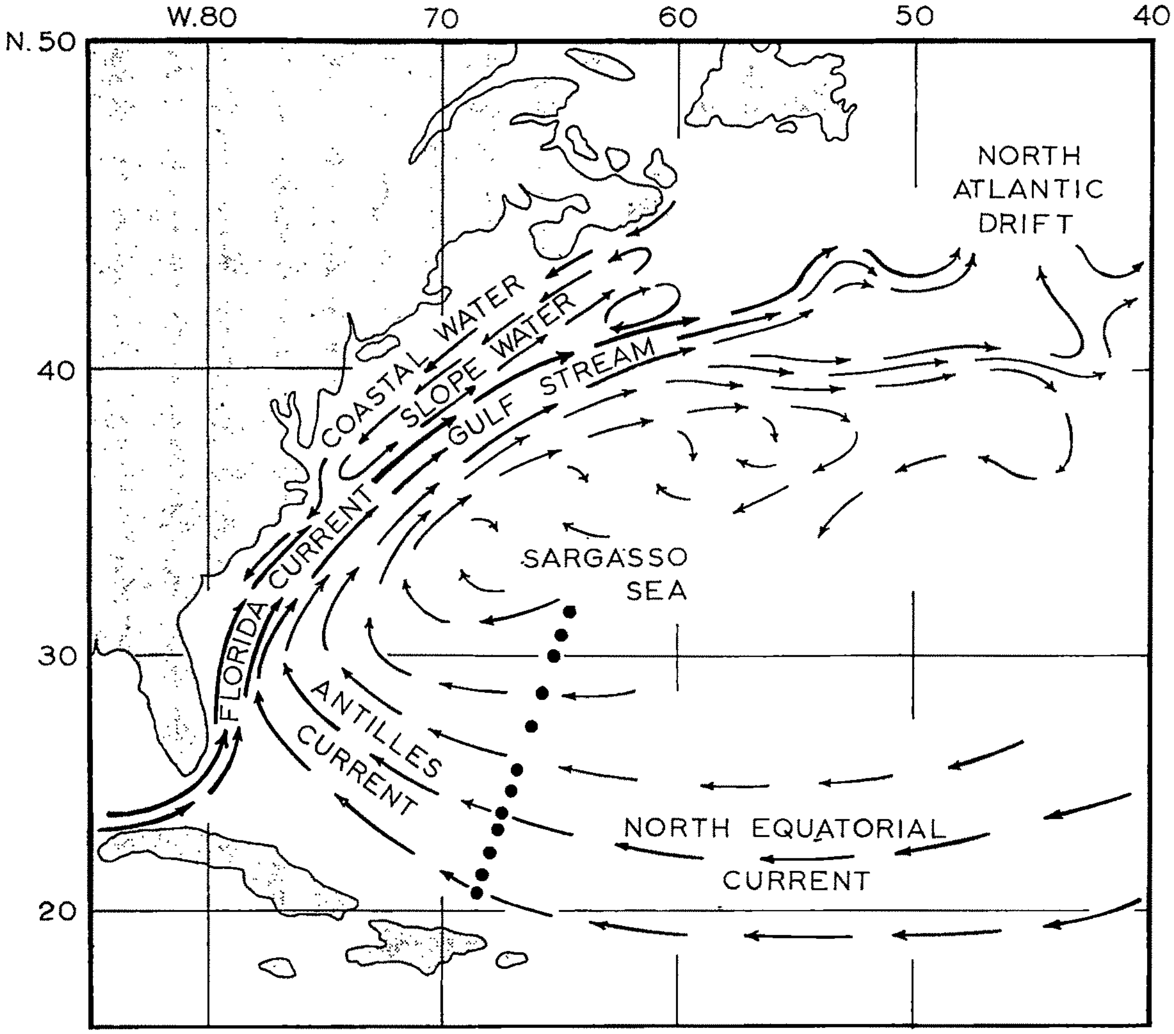

Fig. 3. Atlantic surface currents affecting the distribution of *Anguilla* larvæ. The map also indicates the positions (● ●) of the *Atlantis* stations involved in Fig. 4. (Adapted, after Sverdrup *et al.*, ref. 16, and Iselin, ref. 34)

the sharp focus provided by the Strait of Gibraltar has never been witnessed, despite much study; indeed, Ekman[22] has anticipated me in denying that it occurs, which is already tantamount to saying that the Mediterranean stocks at least are maintained by breeding populations from elsewhere. Quite apart from the difficulties of navigation, it may well be that the distances from the great Mediterranean river-mouths to Gibraltar are already beyond the eels' capabilities.

Supporting evidence comes from another direction. There is a substantial uniformity of condition and unanimity of action in the departure of the eels from the rivers[2]. Yet from time to time isolated individuals are found in adjacent seas in advanced conditions of ripeness; in the Baltic[23], English Channel[19] and Mediterranean[20]. These isolated individuals may be the last survivors of stocks which have migrated from much farther east. Heavy eel-mortalities have been observed even in the Mediterranean[20]; elsewhere, "In consequence of excessively stormy weather this month (Feb. 1655) many thousands of dead eels were cast out upon the banks of the North Loch at Edinburgh, to the admiration of many"[24].

In the Mediterranean, again, are several deeps which offer conditions apparently identical to those of the Sargasso, yet eels do not spawn in them nor anywhere in that Sea[25]. In the open Atlantic the Cape Verde Basin, Monaco Deep and West Indian Basin, all on the obvious migration route, are likewise devoid of young larvæ.

Explanations of the hypothetical long-range migration in the open ocean have ranged from notions of voluntary point-to-point navigations to the idea that the eels first passively ride the Canary Current and are afterwards carried in the North Equatorial Current[26]. A proper scepticism towards all these suggestions has hitherto been inhibited by the inescapable fact of the Sargasso larvæ. Speculation has gone as far as "Les Amours des Anguilles"; the parting words of a legendary watcher by the Rhine may now seem more appropriate[27]: "Ihrem Ende eilen sie zu, die so stark im Bestehen sich wähnen".

The east-coast American migration, by contrast, presents little difficulty. Along that coast the coastal water and immediately adjacent slope water are moving in a south-westerly direction (Fig. 3). Recent *Discovery II* work[28] has confirmed the hypothesis

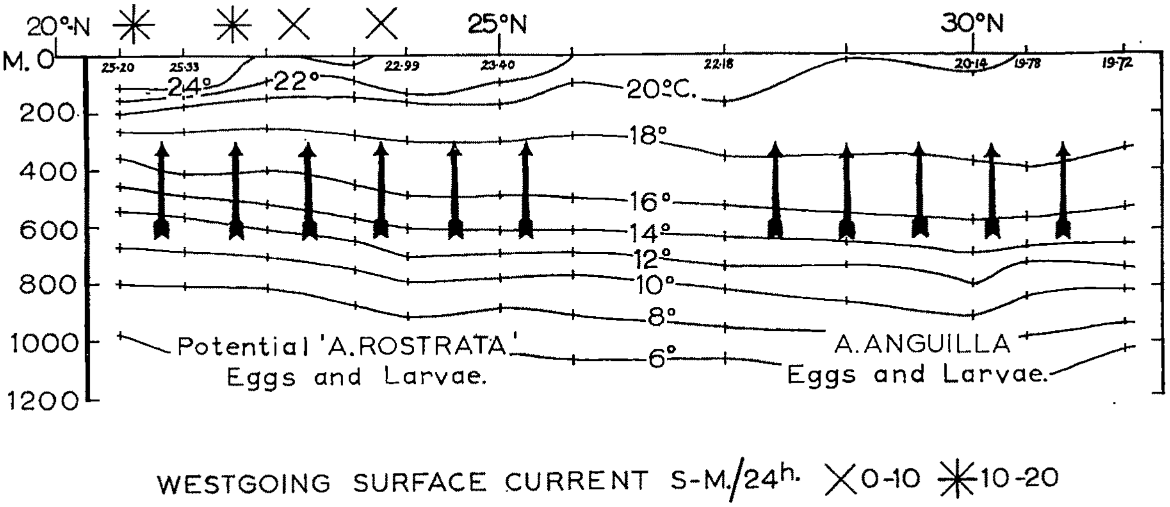

Fig. 4. Section across the *Anguilla* spawning area. Isotherms after Iselin (ref. 34) based on *Atlantis* stations 1208–1219, Haiti to Bermuda, April 7–13, 1932. Surface-current velocities for March inserted after Dietrich (ref. 36)

of Stommel and proved the existence, 150 miles off South Carolina, of a strong south-going current (up to 8½ miles a day) deep under the Gulf Stream. This system provides a simple, rapid and direct path, and without demanding any differences of behaviour among the different eastern groups of American eels. Temperature and salinity gradients encountered on this route[16] are such that active migration would reinforce passive transport. The fate of the Mississippi eels need not concern us.

We may here meet Bertin's demand[2] for a migration theory containing all the observed phenomena of physiology and behaviour. The evidence shows that the debility of the (European) eel which is obliged to drift passively downstream in the current is due to demineralization of the starving body at the inception of gonadial and other hormone activity, and that re-mineralization and resumed liveliness occur when the eel reaches the sea[2,29]. (The survival of silver eels captured and imprisoned in fresh water[15] shows that with gonad-regression continued life is still possible, that is, through re-mineralization accomplished at the expense of the gonad, so that in the early stages the process is reversible.) Thus far no voluntary activity is called for.

With continuing gonadial activity, further demineralization occurs which can only be remedied under conditions of higher ambient salinity. The eel experiences a malaise alleviated by migration towards higher salinity and aggravated by passage into lower-salinity waters; here is the mechanism of the observed halotaxis. Failure to migrate leads, by this stage, to increasing mineral unbalance and to death. The better-adapted American eels migrate until they are trapped in the warmest, deepest part of the North Atlantic Central Water under the Sargasso, in a salinity of $35^{0}/_{00}$–$36^{0}/_{00}$, where the climactic stages of gonadial maturation, de-mineralization and spawning occur. Death after spawning may be assumed; European males experimentally ripened and spawned died within 12–24 hr. of emission[9], while *Conger conger* is known to become more debilitated after spawning[30,31] than any *Anguilla* yet observed.

The reproductive metabolism is clearly geared to the need to produce gametes which will be isotonic or hypertonic to the water in which they are spawned; that metabolism in turn imposes the selection of spawning area. If, as is very likely, many forced spawnings occur short of the Sargasso, unfavourable osmotic and temperature conditions would speedily efface the evidence.

(2) Evidence concerning Possible Temperature Effects and Transport of Eel Larvæ

A substantial body of evidence[32] shows that vertebral numbers in fish populations are inversely correlated with ambient temperatures. Experimental studies, for example, on *Salmo trutta*[33], of effects of temperature in ontogeny, have shown that there is also a supersensitive period in the development of the egg during which a temperature change may have a shock-effect; means of 56·86 and 60·06 vertebræ were obtained in batches of young from the same parents, a difference proportionally similar to that pertaining between whole populations of Atlantic *Anguilla*. Other meristic characters, such as numbers of rays in median and paired fins, are likewise affected[33], not necessarily at the same time or in the same direction.

If we may assume that *Anguilla* shares the common susceptibility to such factors, hydrological data are available to show how phenotypic differentiation may occur.

Consider the rectangle between 20–30° N., 50–70° W. The surface-current system in this region (Fig. 3) comprises the west-flowing North Equatorial Current with its north-westerly continuation, the Antilles Current. Conditions are substantially similar throughout the moving water-mass just defined[34]; any section normal to the direction of flow provides a fair picture of the whole, wherefore the section Haiti–Bermuda given by *Atlantis* Stations 1208–1219[34] may be taken as a basis for discussion of conditions over the eel spawning area (Fig. 4).

Assume a linear spawning area extending from 20–30° N. and at a depth (400–700 m.) below the influence of surface currents. Eel eggs, rising through the lower layers, will encounter a substantially identical temperature gradient until they strike the 18° C. isotherm at about 300 m. From then on several conditions become differentiated simultaneously, roughly in relation to latitude.

Eggs and larvæ at the southern limit pass through the gradient 18–25° C. during the last 250 m. ascent; in particular, they encounter an abrupt 4° rise between 200 and 100 m. which may well have the effect of ending segmentation and so fixing the number of somites/vertebræ in the range 103–111 recognized as typifying '*Anguilla rostrata*'.

At the northern limit, however, the temperature gradient remains gradual right up to the surface, where a maximum temperature of barely 20° C. is encountered. No temperature effect, certainly no shock effect, is likely, wherefore the addition of somites presumably continues to the genetically determined limit and results in the population with 110–119 somites/vertebræ which we recognize as *A. anguilla*.

Further biological effects may be assumed. First, in the '*A. rostrata*' larvæ, the higher ambient temperatures must result in a higher metabolic rate, supported by the higher zooplankton concentrations along their route[35], hence the higher growth-rate and, probably, the shorter larval life; duration of life and growth-rate in the adult have not been studied but may also be affected by the extreme conditions of this earlier phase. For the *A. anguilla* population the converse assumption and observations hold.

Secondly, as in any such system, the Antilles Current runs deeper[16] as well as faster[36] at its periphery. This means that the '*A. rostrata*' larvæ begin to be transported westwards while still at a considerable depth; for the *A. anguilla* larvæ such lateral movement does not commence until they approach the surface, and even then is much slower than in the other case. Consequently our original north–south linear spawning area produces, some weeks after spawning, a surface population of larvæ which lie along a line more or less skewed from north-east to south-west. A spawning-area pattern of any shape or size, lying between the prescribed limits, will be similarly transferred when the resulting larvæ approach the surface.

It will be observed that the zone of *A. anguilla* prelarvæ mapped by Schmidt (Fig. 1) tallies with the hypothesis raised in relation to Fig. 4, and there can be no reason for doubting, from the abundance of stations worked and from our knowledge of the hydrological conditions, that this is the spawning area for this section of the *Anguilla* population. The concentric contours of the early stages are likewise compatible with slow migration at random over an area of weak surface currents.

Schmidt's postulate of a distinct '*A. rostrata*' spawning area to the south-west appears invalid. We are given the limit for larvæ of 15 mm., which, at a moderate estimate, must be a month old; resting in a current system travelling at 10–20 miles a day they must be at least 300–600 miles from their point of hatching and up to twice as far from the spawning area. Considered in relation to the Antilles Current, it is evident that the distribution is not compatible with a source lying within the 15-mm. contour. The 15-mm. contour must enclose the surface, the oblique section, of a solid cone of larvæ of diminishing age the truncated vertex (the spawning area) of which lies deeply embedded very much farther back in the current, practically due south of the *A. anguilla* area and contiguous with it. Geographically there is probably only one spawning area altogether, of which the mass of resulting larvæ becomes obliquely and sharply divided and differentiated by the sheer of the sharply defined current. This analysis removes the need for belief in a critical discrimination of spawning areas by adults of two species, related to micro-isotherms[8], bottom topography or some other biologically improbable factor.

In fairness to Schmidt, it must be said that he lacked much of the information now available and that his terms of reference from his Government were to locate the birthplace of the European eel. The '*A. rostrata*' larvæ were, to him, an unexpected nuisance. In the area now suggested as the source of the '*A. rostrata*' phenotypes the Danish Expeditions took only a score of stations[37]; those of the R.V. *Margrethe* were worked in during November–December 1913, too late in the year, while the remainder, at miscellaneous dates and shallow depths, were worked by amateurs from commercial vessels, in a region of rapid currents and, on my hypothesis, minute deep-lying prelarvæ. Closing nets were not used.

It may be objected that '*A. rostrata*' is said to breed during January–February, *A. anguilla* during February–March[3,7]. Against this simple statement must be balanced the fortunes of collecting, the lengths of overall journeys from various starting-points, disparities in sexual maturation, velocities of currents at various possible migration-depths, durations of spawning periods and annual variations in all these; effects of temperature on rates of hatching and early development and rates of ascent of larvæ over different parts of the spawning area. The criticism is more easily answered than made.

'*A. rostrata*' larvæ reach their limit of 60–65 mm. in about nine months and metamorphose into 'glass eels'[3]. Many, still travelling on the periphery of the Gulf Stream system, lie along the North American coast which they approach as pigmented elvers the next spring, a year after hatching. Some laggards colonize brackish ponds in Bermuda[38]; vast numbers of *A. anguilla* all by-pass that island.

A. anguilla larvæ travel mainly on the inside of the current system (some being trapped for a year or more in the Sargasso[3]) so that large numbers travel east and north-east across the Atlantic. Metamorphosis occurs off the edge of the Continental Shelf, except in larvæ which penetrate the Mediterranean to beyond the heel of Italy. Lower temperatures and metabolic rates prolong the pelagic phases to three years and extend the limit of growth to 75 mm.[3].

Environmental conditions affecting metamorphosis have been little studied. The limits of successful larvæ of both groups coincide with the spring surface isotherm for 8° C., which marks the margin of the Gulf Stream system and coincides with the edges of the Continental Shelves, but there are many complicating factors to be considered: turbidity of inshore waters, lateral mixing with lowering of temperature and increased oxygenation, upwelling of cold water at the edges of the slopes (and off Bermuda ?) and possible changes in salinity relations which would affect the hydration observed at metamorphosis. The situation is too complex for theoretical consideration.

It is, however, certain that thyroid secretion is important at metamorphosis; Murr and Sklower[39] have shown that in the late leptocephalus the thyroid increases to ten times its previous size and regresses again in the glass eel. This mechanism must ultimately be under genetic control (modified by ambient temperatures through metabolic rates); '*A. rostrata*' in mid-Atlantic and *A. anguilla* in the tropical Atlantic normally perish without making landfall and metamorphosis is delayed only for part of the Mediterranean transit. In both, therefore, whether forms or species, the hormone regulatory system must act ultimately regardless of unfavourable environmental conditions; we shall need this point again later.

The proposition of Schmidt[3] (p. 204, lines 20–40: "How do the masses of larvæ in the Western Atlantic sort themselves out . . . ?") has led to misunderstanding, especially among lay authors. The situation is, that of the mixed aggregations of larvæ, those which make landfall too soon, too late, or not at all are doomed to perish; the former because their hormone mechanism cannot be triggered early enough by environmental conditions, the latter because the same mechanism decrees that metamorphosis can no longer be delayed. The process is not a sorting, but rather an elimination, of the mis-directed and consequently ill-adapted.

(3) Implications of the New Hypothesis

As a syllogism, the new hypothesis may at least claim parity with Schmidt's, since both theories provide an explanation for the origin of the European eel larvæ and both make a single unsubstantiated assumption. As a biological proposition, however, the probability of the assumed effect of temperature, with its numerous precedents, may be considered more reasonable than that of a 3,500-mile directive migration for which there is no parallel among fishes.

The differentiation of *A. anguilla*/'*A. rostrata*' phenotypes is shown to be credible without genetic intervention; the need for a return migration by European eels to the Sargasso has been removed, so that this problem may be considered divorced from any assumption that it must occur; and we are left with the implication, seemingly more likely and no less remarkable, that Europe and North Africa are regularly colonized by eels of American ancestry doomed to perish in a fruitless suicide-migration.

It remains to provide an explanation of the physiology of the European eel. We know that males attain the age of 7–12 years, females 9–19 years in fresh water[2]; we also know authenticated cases of eels in captivity attaining an age up to 88 years under conditions in which sexual maturation was suppressed[10,15]. The disparity is remarkable; many cases are known of the antagonism between growth and reproductive metabolism, and of animals which breed once and then die; but there is surely no parallel to this. The desperate rapacity of the eel is well known; moreover, Bertin[2] shows that growth-rates vary enormously in different European rivers, evidently in relation to size of water and available supply of food. From this evidence and from considecations of early larval life an explanation can be drawn.

Migration and sexual maturation in *Anguilla* are controlled by a hormone system—hypophysial[40], thyroidean[41] and gonadial[42]—which is certainly genetically determined and, by my hypothesis, preconditioned by early environment. Growth in length appears to be genetically limited[10,43], but growth in bulk is subject to external environmental conditions of temperature, living-space and supply of food. Under American conditions (fishery statistics[10] almost permit us to say St. Lawrence and Great Lakes conditions) of higher ambient temperatures in the larval stages, larger rivers and better supplies of food throughout life, the predetermined sexual maturation and environmentally determined growth-metabolism are synchronized in a viable life-cycle. Under less-favourable European conditions, the predetermined hormone system functions prematurely, and the mechanism of sexual maturation is invoked before the body can sustain its consequences. We have already seen this hormone system in action under unfavourable conditions in mid-Atlantic larvæ; if it can act catastrophically at the first metamorphosis it can surely do so at the second? The disparities in mean weights of American and European eels point to this view, as do the longer stays of the females, the gonads of which have, under optimum conditions, to accumulate greater resources of food. The disparities between American and European eels on their departure likewise fit the picture; the European eel delays to the last possible moment and the migration livery appears before the still premature (and unnecessarily premature) migration is invoked. Environment may advance migration activity a little (in the American eel) or retard it (in the European), but outside the permitted range of variation, in the adult as in the larva, there can be no modification of an inexorable predetermined system.

Since selection pressure upon the Atlantic *Anguilla* acts only in relation to American conditions there is no means by which the deadlock of the 'European' eels can be broken; they represent, in perpetuity, the waste of a major part of the American eels' breeding-potential, compensated for by the adequate numbers of the latter and the ten million or so eggs[10] which a female can produce.

Conditions for the proof of either hypothesis are easily formulated, if difficult to execute. Schmidt's requires the capture of ripe 'European' eels in the spawning area. Mine, the easier, would require experimental production of '*A. rostrata*'-type larvæ from artificially fertilized 'European' eel eggs; alternatively, from eggs collected at the northern limits of the original *A. anguilla* spawning area. The last experiment may have been performed already, quite inadvertently, unknowingly and successfully, by Fish[5].

On July 16, 1925, the *Arcturus* collected four eggs from 500 fathoms at 32° 02′ N., 65° 00′ W., which were reared in the laboratory by Fish and carefully and responsibly reported as *A. rostrata*; criticism of this identification[6,7] does not seem to be conclusively destructive. One larva was reared and had "between 105 and 110 muscle segments" when it died at 10 mm. An embryo had "at least 105 and not more than 109 segments", about 64 of them pre-anal and 41 post-anal. The temperatures of the water during incubation were recorded: 27·7° C. when cleavage began to 23·9° C. at hatching, a range of the order of 10° C. higher than that which would have been encountered in Nature. Thus, from north of the original *A. anguilla* ground were reared, under conditions in which a temperature effect must appear inevitable, larvæ which were arguably of '*A. rostrata*' type. That the eggs were so far north and late in the year and lacking a concentrated oil-globule, facts cited against the *Anguilla* identification, may be explained by the assumption that they merely represented one of many mistimed and misplaced spawnings and might well have died immediately but for their respite under laboratory conditions.

I would like to express my thanks to numerous colleagues, notably Dr. E. Trewavas and Mr. P. H. Greenwood, who have been my patient *advocati diaboli* during this work.

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INFORMATION THEORY AND ITS APPLICATIONS TO FUNDAMENTAL PROBLEMS IN PHYSICS*

By Prof. L. BRILLOUIN

Columbia University, New York

THE scientific theory of information, developed during the past few years, has yielded some very important applications in the field of telecommunications, but it has also led to many interesting discussions about the fundamental definitions of experimental science. Among other things, it has obliged the physicist to re-examine the role of experimental errors and has required a complete re-appraisal of their actual importance.

Formerly, errors were usually considered as a secondary effect, a nuisance that could be neglected in most occasions, and which should be ignored by theory. The assumption was that errors could be made as small as might be desired by careful instrumentation, and played no essential part. This was the point of view of mathematicians discussing the axioms of geometry, and most physicists accepted, implicitly or explicitly, this kind of idealization. Modern physics has had to get rid of these unrealistic schemes, and to realize the unpleasant fact that errors cannot be made as small as one wishes, but must be taken into account as an integral part of the theory.

Errors, Uncertainties and Observations

Until the end of the nineteenth century, most scientists assumed that experimental observations could reveal the 'laws of Nature'; of course, observations were perturbed by all sorts of errors, but it was customary to generalize the imperfect data available and to formulate simple mathematical laws; these *exact* laws were supposed to govern the outside world, whether it could be observed in principle or not. For example, Newton's laws of mechanics and of universal gravitation were accepted as rigorous, even though they had been verified only within the limits of experimental error.

The first difficulties were encountered in connexion with statistical thermodynamics: How was it possible to derive irreversible thermodynamics from strictly reversible mechanical laws? There was also the problem of determinism, which was assumed to be proved by scientific investigations, although in practice it remained impossible to verify such a rule by any experimental device.

With Heisenberg's 'uncertainty principle', the importance of errors in observations came into the foreground. Physicists realized that it was impossible to measure accurately, and at the same time, a co-ordinate x and its momentum p_x, and that the corresponding errors were coupled by the relation:

$$\Delta x \,.\, \Delta p_x \geqslant h \qquad (1)$$

Any experiment measuring x with an error Δx perturbs the system and introduces an unknown change Δp_x in p_x, making its exact determination impossible. It is a fundamental and inescapable fact that an observation always creates a perturbation. If you have a physical system which is completely isolated and unperturbed, you cannot observe it. An observation necessarily requires a certain temporary coupling between the system and a measuring instrument; this coupling results in a perturbation of the observed system.

This general remark was given a precise statement in a law discovered by me, and called the 'negentropy principle of information'. It states that an observation yields a certain amount of information ΔI, that this information can be measured quantitatively, and compared with an inevitable increase in entropy ΔS in the measuring device during the experimental measurement. The net result is (in entropy units):

$$\Delta S \geqslant \Delta I \quad \text{or} \quad \Delta I + \Delta N \leqslant 0 \qquad (2)$$
$$\text{with } \Delta N = -\Delta S \quad \text{neg(ative) entropy}$$

These conditions mean that a finite amount of energy ΔE must be degraded and changed into heat:

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* Based on a series of five lectures delivered at King's College, London, during October 21–29, 1958. Work done under contract *Nonr* 255 (56).

$$\Delta E = T\Delta S \geqslant T\Delta I \text{ (}T\text{, absolute temperature)} \quad (3)$$

The definition of the quantity ΔI can be summarized in a simple way[1]: let P_0 be the number of equally possible cases before the measurement, and P_1 the number of such cases after the observation. Then, by definition:

$$\Delta I = k \ln \frac{P_0}{P_1} \quad (4)$$

where k is Boltzmann's constant. If the accuracy is very high, P_1 becomes very small and the amount of information is very large. Infinite accuracy, with infinitely small error, would mean an infinite increase in information; hence an infinite amount of energy ΔE is degraded, which is quite impossible[2].

A similar opinion has been expressed by Born[4,5] in a series of papers based upon the obvious fact that every method of observation has its limitations, making experimental errors unavoidable. This is, in a general way, what is stated more precisely in our conditions 2.

When extreme accuracy is required, a new restriction arises, which makes it even more difficult to make a measurement of very small distances. It may be shown (ref. 1, p. 235) that a very large amount of energy ΔE is needed for the observation of a distance x within a very small error Δx:

$$\Delta E \,.\, \Delta x \geqslant \tfrac{1}{2}\, hc \quad (5)$$

This very large energy ΔE is partly dissipated, according to the previous conditions 2 and 3, and when Δx becomes extremely small (smaller than 10^{-13} cm., for example), the new condition 5 requires an expenditure in energy very much higher than that which would result from equation 3.

The preceding conditions 3 and 5 can be explained in simple terms. It has been realized since the work of Ising that Brownian motion (thermal noise) sets a limit to the accuracy of observations. Thermal agitation involves energies of the order of kT per degree of freedom. For a reliable observation of one degree of freedom, an energy larger than kT must be used in order to overcome irregular motions of magnitude kT. If the observation is made on many degrees of freedom, it will require an energy proportional to T; this energy is degraded, and yields an increase of entropy ΔS independent of T. This is practically the mechanism underlying equations 2 and 3.

As for condition 5, a simple numerical computation shows[3] that the energy ΔE, translated into electron-volts, corresponds to the many millions of volts required to measure the cross-sections of particles having very small diameters, Δx; relation 5, in fact, is applicable to the synchrotrons or other powerful accelerators used for measuring the very small cross-sections encountered in collisions of atomic particles.

To sum up: an observation is an irreversible process, necessarily involving an increase of entropy in the measuring apparatus: the information obtained is paid for in negentropy. As Gabor has commented, "You can never get something for nothing, not even an observation". This remark has far-reaching implications, which will now be discussed.

The Objective World and the Problem of Determinism

In a brilliant discussion, Schrödinger has explained[6] how much we owe to the Greek philosophers, from whom we inherited many fundamental ideas. These concepts have been extremely useful, but we have now reached a point where we must revise them drastically. The scientist used to step back into the role of an external observer, and to assume the existence of 'a real, objective world around us', governed by accurate mathematical laws (the laws of Nature), according to which it would proceed unperturbed, whether we observe it or not.

The modern point of view is different: when we are not making any observation, it must now be admitted candidly we do not know what is happening; and when we make an observation, we certainly perturb the 'outside world', by some coupling between observer and the observed. So the assumption of accurate laws of Nature is gratuitous; it is a philosophical creed, but it is not supported by experimental facts. All we can prove is the existence of certain correlations: given the result of a certain experiment, we are able to predict (within certain limits) the possible outcome of a later experiment. This, however, does not require any objective outside world: that is an additional assumption which may provide a convenient model for most large-scale experiments, but the model is definitely wrong at the atomic or sub-atomic scale.

Bridgman has repeatedly emphasized the danger of introducing into our theories too many unmeasurable quantities. Sooner or later these unobservable concepts will have to be rejected, and this will often mean a very painful re-appraisal of actual facts and data.

In many cases, strict causality must be replaced by statistical probabilities; a scientist may or may not believe in determinism. It is a matter of creed, and belongs to metaphysics; physical experiments are unable to prove or to disprove it. This general point of view may be called the 'matter-of-fact' point of view.

Relations 1 to 5 above show that it is quite impossible to eliminate experimental errors completely. They are not only a practical limitation but also they represent an absolutely unavoidable feature of the experimental method. Laplace invented, more than a century ago, a demon who was supposed to know exactly the positions and velocities of all atoms in the universe, and to compute exactly the future evolution of the whole world. The present discussion constitutes an exorcism of Laplace's demon. Both the uncertainty principle and the negentropy principle of information make Laplace's scheme of exact determinism completely unrealistic.

In order to measure very accurately the initial positions and velocities of all the atoms in the universe, the demon would need an infinite amount of energy, according to equations 3 and 5. The exact determination of initial conditions is thus physically impossible.

The negentropy principle of information had already provided a definite answer to the paradox of Maxwell's demon; it also eliminates Laplace's demon without further discussion. Experimental errors cannot be made as small as one may wish, for they belong to the actual facts of experiment and must be included in the theory.

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PHOTOREACTIVATION OF NUCLEIC ACID FROM TOBACCO MOSAIC VIRUS

By F. C. BAWDEN, F.R.S., and A. KLECZKOWSKI
Rothamsted Experimental Station, Harpenden, Herts

SOME types of injury caused by ultra-violet radiation to systems containing nucleic acids can be reversed by subsequent exposure to visible light. Irradiated viruses cannot be directly photoreactivated; but, except for strains of tobacco mosaic virus, all those yet reported on can be reactivated by exposing recently infected hosts to visible light[1]. In other words, when irradiation has destroyed about 99 per cent of the initial infectivity of a preparation, only strains of tobacco mosaic virus have shown the same residual infectivity whether inoculated hosts are kept in light or in darkness. Two explanations for their exceptional behaviour are self-evident: (1) their nucleic acids may be exceptional in not undergoing the type of change that is reversed by visible light; or (2) the manner in which their nucleic acids is combined with protein may prevent them from undergoing the reversible changes. *A priori*, as the morphology of tobacco mosaic virus differs from that of photoreactivable viruses, the second explanation seemed more likely to be true. Also, there is evidence that the protein protects against ultra-violet radiation, for the nucleic acid needs much more irradiation to be inactivated to a given level when in the virus than when free[2]. That the manner of combination with protein, or the quality of the protein, also affects sensitivity to irradiation is shown by the fact that different strains of the virus inactivate at different rates when intact, although their separated nucleic acids are equally sensitive[3].

The discovery that preparations of the nucleic acid from tobacco mosaic virus can be infective[4,5] made it possible to test these alternative explanations. This we have done and found that nucleic acid irradiated when freed from its protein can be photoreactivated. This alone would not establish the fact that the protein protects against the reversible type of irradiation damage, for the protein might prevent visible light from reversing the damage. However, the point seems to be fully established by the fact, shown in Table 1, that nucleic acid separated from irradiated virus was not photoreactivated. The solution of tobacco mosaic virus was irradiated so that about 99 per cent of the initial infectivity was destroyed, and the residual was the same whether measured on plants kept in light or darkness. The nucleic acid was separated from the virus by the phenol method[5] and its infectivity compared with that of nucleic acid similarly separated from unirradiated virus. The relative infectivities of the two nucleic acid preparations were of the same order as those of their parent virus preparations, and were the same whether the test plants were kept in light or darkness after inoculation.

Table 1. FAILURE OF LIGHT TO AFFECT INFECTIVITY OF NUCLEIC ACID FROM IRRADIATED TOBACCO MOSAIC VIRUS (T.M.V.)

Inoculum	Dilution of the inoculum	Total number of local lesions obtained on twelve half-leaves	
		Dark	Light
Irradiated 1 per cent T.M.V.	1/50	401	416
Non-irradiated 1 per cent T.M.V.	1/2,000	783	860
	1/10,000	397	417
	1/50,000	132	139
Nucleic acid from irradiated 1 per cent T.M.V.	1/1	45	42
	1/5	10	7
Nucleic acid from non-irradiated 1 per cent T.M.V.	1/20	198	172
	1/100	38	23
	1/500	9	7

5 ml. of a 1 per cent solution of tobacco mosaic virus in *M*/60 *p*H 7·0 phosphate buffer were irradiated at 3,030 μW./cm.^{2} in a Petri dish of dia. 6·6 cm., so that 2·5 joules were absorbed and scattered per 1 mgm. The number of lesions obtained with the intact virus cannot be directly compared with those obtained with the nucleic acid, for they came from different tests on different sets of *Nicotiana glutinosa* plants. 'Dark' and 'Light' mean respectively that the plants were in darkness or daylight after they were inoculated.

Table 2. PHOTOREACTIVATION OF NUCLEIC ACID IRRADIATED WITH ULTRA-VIOLET LIGHT AFTER ISOLATION FROM THE VIRUS

Time of irradiation (min.)	Absorbed energy (joules per mgm.)	Dilution of inoculum	Number of lesions		Log$_{10}$ of remaining proportion of initial infectivity			
			Dark	Light	Found Dark	Found Light	Computed Dark	Computed Light
1·25	0·63	1/1	297	722	−1·1	−0·53	−1·0	−0·5
3·5	1·76	1/1	11	194	−2·7	−1·4	−2·8	−1·4
0	0	1/5	596	543	—	—	—	—
0	0	1/50	91	100	—	—	—	—
0	0	1/500	12	7	—	—	—	—

The undiluted nucleic acid was a 0·66 mgm./ml. solution in *M*/60 *p*H 7·0 phosphate buffer, of which 2·5 ml. were exposed to radiation of intensity 870 μW./cm.^{2} in a Petri dish of dia. 4·5 cm. The log. of the remaining proportions of the initial infectivity were found from the curve obtained by plotting the numbers of lesions produced by the control preparation against the log. of their dilutions. The computed values were obtained from the equation $\log_{10} p = -kv$, where p is the remaining proportion of the initial infectivity, v is the energy absorbed in joules per mgm. and k is assumed to be 0·79 with photoreactivation ('Light') and 1·58 without photoreactivation ('Dark').

Nucleic acid preparations have only a small fraction of the infectivity per unit of phosphorus of intact virus and most of this must be destroyed to demonstrate photoreactivation. Hence, the test plants (*Nicotiana glutinosa* L.) must be highly susceptible, and ours were raised in shade and kept at 37° for a day before they were inoculated. Both these treatments increase susceptibility to infection by intact virus but do so much more when nucleic acid is the inoculum. Table 2 shows the results of an experiment in which two aliquots of nucleic acid made by the phenol method from a 2 per cent virus solution were irradiated to different extents, after which their infectivity was compared with that of unirradiated nucleic acid inoculated at three concentrations. The nucleic acid was kept at 0° between the time it was made and used as inocula, and samples were irradiated as thin layers in Petri dishes kept rocking in a bath of iced water. Twelve plants were used, and each solution was inoculated to twelve half-leaves distributed equally on each plant and at each leaf position. After inoculation, six plants were exposed to daylight and six put in darkness. The greater relative infectivity of the irradiated nucleic acid in plants in the light is obvious. With or without photoreactivation, inactivation approximately follows first-order kinetics, with photoreactivation equivalent to halving the dose of radiation. This factor of two places the nucleic acid of tobacco mosaic virus second only to potato virus *X* when plant viruses are listed according to the extent they show photoreactivation[1], but as the other viruses were irradiated only when intact, their nucleic acids might show the phenomenon more strongly if irradiated free from their protein.

McLaren and Takahashi[2] found that the infectivity of nucleic acid preparations was halved when 1 mgm. absorbed 0·43 joule. They do not say how their inoculated plants were treated, but it is likely they were placed in the light, for this value is close to the 0·38 joule which can be calculated from the data in Table 2 for plants in the light, whereas the value for 50 per cent inactivation without photoreactivation is 0·19.

Siegel, Wildman and Ginoza[3] concluded that the differences between sensitivity of different strains of tobacco mosaic virus reside in the nature of the bonding between the protein and nucleic acid. As none of the strains yet tested, although they differ in their sensitivity to inactivation, shows photoreactivation when irradiated intact, all seem to share a type of bonding that protects the nucleic acid from changes reversed by light. We have not attempted to see whether recombining separated nucleic acid with the protein would prevent photoreactivation, but the type of bonding in 'reconstituted' virus particles seems to differ from that in the original virus because the recombination does not restore the original degree of resistance to inactivation by irradiation[3]. Even the most sensitive strain of tobacco mosaic virus requires much more energy to be inactivated than does potato virus *X*, which has the same content of nucleic acid. It seems, then, that the nucleic acids of different viruses may resemble one another in sensitivity to irradiation and in undergoing more than one type of change, but that their proteins protect them to very different extents from changes of different kinds. It is possible that we have not measured the full potential of tobacco mosaic virus to be photoreactivated, for separating the nucleic acid from its protein may have changed some of the groups that otherwise could have undergone reversible changes.

We used two low-pressure mercury lamps, both of which have most of their radiation of wave-length 254 mμ, and one of which had a filter excluding wave-lengths shorter than 240 mμ. Both gave qualitatively similar results: photoreactivation when the separated nucleic acid was irradiated, but not when intact virus was, whether the inoculum was intact virus or nucleic acid separated from the irradiated virus.

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OBITUARIES

Sir Claude Gibb, K.B.E., F.R.S.

SIR CLAUDE DIXON GIBB, who died suddenly in the United States on January 15, was one of the outstanding engineers of our time. He was also pre-eminent as an administrator, manufacturer and scientist. He was sixty years of age.

After qualifying at the University of Adelaide, he became a senior research assistant in the Engineering Laboratory there after a short interruption as a pilot in the Royal Australian Flying Corps. He went to Great Britain in 1924 to gain experience as a fitter with the firm of Messrs. C. A. Parsons and Co., Ltd. Such was his ability that he was made general manager in 1937 and managing director in 1943. In 1940, loaned by his Company to the Ministry of Supply, he rapidly moved from engineering assistant to director-general, Munitions Production, and afterwards to director-general, Armoured Fighting Vehicles, and chairman of the Tank Board.

He was elected a Fellow of the Royal Society in 1946 and has been noted for his particular interest in research, originally on steam turbine components and latterly in nuclear work for the production of power. In 1946 he was appointed a member of the Board of the National Physical Laboratory, and became a member of the Council of King's College, Newcastle upon Tyne, in the same year.

In 1947 Sir Claude was appointed a member of the Advisory Council on Scientific Policy and became chairman of the Committee on Research and Productivity. He has also been chairman of the Sectional Committee on Engineering of the Royal Society and was a member of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. In 1949 he was a vice-president of the British Association and in 1951 president of Section *G* (Engineering) of the Association. He was also chairman of the Board of Governors of the Rutherford College of Technology.

Sir Charles's own scientific work has been described in technical papers given to the major institutions in Canada, Australia and the United Kingdom. Under him, Messrs. C. A. Parsons have an order for a 550 MW. set for the Thorpe Marsh Power Station—at this time the largest in the world. As a result of his work, this Company became the main contractors for the first nuclear power station, namely, Calder Hall. The Company has also been engaged in the very large items of equipment for Chapelcross Power Station and the large new power station under construction at Bradwell. Sir Claude was also mainly instrumental in the negotiations in Italy to build a nuclear power station at Latina, near Rome.

Sir Claude received many well-deserved honours. Such is the brilliant record of a man who from fundamental knowledge of science with a strong basis of practical imagination brought so much honour to the firm and country which he chose as his own.

T. W. F. BROWN

Prof. W. Wardlaw, C.B.E.

The very large number of scientists who knew him personally were grieved to learn of the death of Prof. William Wardlaw on December 19, at the age of sixty-six.

Wardlaw was educated at Newcastle upon Tyne, first at Rutherford College, and then at Armstrong College, in the University of Durham. Although he lived for a large part of his life in the Midlands and in London, he never forgot his connexion with Northumberland and often referred with pride to his early days in the North Country. In 1918 he joined the staff of the Department of Chemistry, University of Birmingham. He proved to be an admirable university teacher and progressed to the rank of senior lecturer in inorganic chemistry. He was appointed to the chair of physical chemistry in the University of London, tenable at Birkbeck College, in 1937, and he held his professorship for twenty years until his retirement in 1957, when the title of professor emeritus was conferred on him.

For more than forty years Wardlaw carried out valuable research in inorganic chemistry. During the early stages of his career he investigated some inorganic oxidation processes and made contributions to the chemistry of molybdenum. In the 1930's his interest turned to the stereochemistry of metal complexes. This subject continued to hold his attention for the rest of his life, and by his work he made an important contribution in this field of study. On taking up his appointment in London, Wardlaw had barely succeeded in getting his new department organized when the Second World War began and a halt was called to his research activities. At the conclusion of hostilities he was faced with two major tasks. He had to build up afresh a research group, and to plan and equip a new department, since his College was transferred to new quarters in Bloomsbury. He attacked both tasks with characteristic vigour. An extensive programme of research on the esters of transition metals was initiated, and under his direction a flourishing research school was developed in the new well-equipped laboratories. The results of this last phase of his research work have had an important influence on the development of modern ideas of the inter-relation of physical properties with molecular structure.

Wardlaw held strongly the belief that university scientists should not lead an 'ivory tower' existence, and he seized every opportunity to broaden the impact of chemistry upon the community. He sought to widen the range of contacts of scientists in the universities, in industry, and in research associations, and his membership of the Society of Chemical Industry dated from 1917. He was extremely sympathetic towards the difficulties which faced science masters in schools through poor laboratory accommodation, and often spoke up strongly on this point. Scientific publication interested him enormously, and he gave considerable thought to the best ways of dealing with the ever-increasing volume of chemical papers. To the professional societies he gave generously of his time and found much pleasure in this service. In later life he reached high office in these societies, but his many friends testify that his support was equally enthusiastic at the commencement of his career.

During the difficult period 1940–48, he was honorary secretary of the Chemical Society, and he became president for 1954–56. His first membership of the Council of the Royal Institute of Chemistry dates from 1929 and at the time of his death he was president. To be elected president of both the Chemical Society and the Royal Institute of Chemistry is an honour accorded to few, and is a measure of the esteem in which Wardlaw was held by his professional colleagues and the confidence which his sound judgment inspired.

He had strong sympathy with the aims of the British Association, and the active part he played in its affairs demonstrates his strong conviction that the chemist has responsibilities which extend beyond the boundaries of his profession. In 1952 he presided over the meetings of Section *B* (Chemistry) and more recently took office as one of the general secretaries. He was closely connected with the current developments in the activities of the Association.

During the Second World War Wardlaw was a joint secretary of the War Cabinet Scientific Advisory Committee, after which he became scientific advisor to the Committee of Appointments in the Ministry of Labour and National Service. Undoubtedly he had a flair for accurate judgment of character and ability, and his advice has been of great national benefit. In 1949 he was created C.B.E.

Wardlaw was always sympathetic to his students and ready to assist in their problems : they responded to his interest with a deep sense of respect and grateful affection. He could not bear slipshod work or laziness, and on occasion his comment and censure could be forthright.

Being a humorous man of much charm, he had a great many friends. His colleagues at Birkbeck College and throughout the University of London always welcomed his company and found joy in his unvarying friendliness. His devoted and wholely selfless service to learning, the public welfare, the advancement of science and the selection and production of scientists, add up to a life-time's work of inestimable value. Scientists, and especially chemists, owe a great deal to Wardlaw, and it is hard to realize that no longer will it be possible to call on his services or to seek his wise counsel.

In 1932 he married Doris Whitfield, who had herself been trained as a chemist, and he never failed to pay tribute to her sympathetic understanding and help in his work. She and their daughter survive him.

W. G. Overend

Prof. A. R. Fulton, M.B.E.

Angus Robertson Fulton, emeritus professor of engineering and drawing in the University of St. Andrews, died at his home in Dundee on November 21.

Born in Dundee on June 23, 1871, he suffered the early misfortune of being left an orphan at the age of five. This affected his opportunities for education, but by courage and determination he acquired a training as an engineer. On qualifying, he worked for some years with Hurst and Nelson, of Motherwell, and it is a testimony to his ability that, although up to that stage he had no university degree, he was invited by Prof. T. Claxton-Fidler to be his assistant in the Engineering Department of University College, Dundee. He spent the rest of his professional life, from 1902 until 1946, on the staff of that Department.

He graduated B.Sc. in 1907, and was the main assistant, first, to Prof. Claxton-Fidler, then to his successor, Prof. A. H. Gibson. During the First World War he served for some time in the Royal

Flying Corps and worked as an investigator of accidents caused by mechanical failures. For this work he was mentioned in dispatches and was made M.B.E.

On returning to Dundee, he continued his researches on stresses in materials and received the degree of D.Sc. in due course. He was appointed professor of engineering and drawing in University College, Dundee, in 1920, and held this post until he retired in 1946. During 1939–46 he was also principal of University College, Dundee. In both posts he was highly respected by his colleagues for his academic abilities, for his powers as an administrator, and for his sincerity.

J. DICK

NEWS and VIEWS

Zoology at Cambridge:

Sir James Gray, C.B.E., F.R.S.

SIR JAMES GRAY, who is to retire from the chair of zoology at Cambridge in September, has been one of the chief architects of the structure of modern British zoology. He and the men and women he has trained have been largely responsible for the growth of experimental zoology and for the replacement of comparative anatomy by studies of the living animal in zoological laboratories throughout the Commonwealth. After serving with distinction in the First World War, he returned to Cambridge as Balfour student and then as reader in experimental zoology; his cytological researches during this period culminated in the publication of "Ciliary Movement" in 1928 and "A Textbook of Experimental Cytology" in 1931. The design and building of the new zoology laboratory at Cambridge during 1932–34 provided him with his first major administrative task and it is a tribute to his skill that few people who work there to-day would wish to change the building. He was appointed to the chair in 1937 at a time when his interests were moving away from cytology to the analysis of animal movement, and he pioneered the application of physical principles to many different aspects of this study. Until after the Second World War his work was perhaps not widely known to the world at large, but this was remedied in 1951 by a series of Christmas Lectures at the Royal Institution, which were afterwards published under the title "How Animals Move". Before, and even more after, the War he has been active in the wider spheres of administration, being president of the Marine Biological Association, twice on the Council of the Royal Society, a member of the Agricultural Research Council during 1942–47 and for many years a development commissioner and chairman of the Advisory Committee on Fishery Research. This year he is president of the British Association. As editor, almost from its inception until 1954, of the *Journal of Experimental Biology* he has made a notable contribution to clarity in the publication of scientific results. Altogether, his influence will continue to be felt in his subject for many years.

Prof. C. F. A. Pantin, F.R.S.

DR. C. F. A. PANTIN, who has been elected to succeed Sir James Gray as professor of zoology in the University of Cambridge, has been reader in invertebrate zoology in the University since 1937. After taking his degree from Christ's College, Cambridge, he was physiologist to the Marine Biological Laboratory, Plymouth, during 1922–29, and returned to Cambridge as Harding Lecturer and Fellow of Trinity College in 1929. His researches have ranged over a wide field of invertebrate zoology. During 1923–31 he published a series of papers which laid the foundation of our knowledge of amœboid movement; in 1931 he established the role of calcium in the osmotic regulation of the body fluid of the marine worm *Gunda* (*Procerodes*). His analysiis during 1934–36, of the physiology of crustacean muscle was the starting-point for extensive subsequent work on this tissue; at this time also he became interested in the Coelenterata, the neuromuscular physiology of which he has continued to clarify in a series of papers since that date. On his appointment to the readership, he found time to study the terrestrial Nemertines, hitherto largely unknown in Britain. His experiments have been characterized by a clarity and simplicity which has made them the basis of practical courses in comparative physiology throughout the world; his insistence on the need for a parallel study of structure and function has done much to unify the different approaches to the study of invertebrate animals.

Dr. Pantin was president of Section *D* of the British Association in 1951, Croonian lecturer of the Royal Society in 1952 and is now president of the Linnean Society. He has given much assistance and encouragement to marine biology overseas, particularly in New Zealand and Brazil. Since 1947 he has been editor of the *Quarterly Journal of Microscopical Science*. His wide experience and skill as a teacher will ensure the continuation of the high standards of zoology at Cambridge.

California Institute of Technology, Radio Observatory:

Dr. J. G. Bolton

JOHN GATENBY BOLTON has been appointed the first director of the California Institute of Technology's newly established Radio Observatory, which is situated near Big Pine in the picturesque Owens Valley of California. Bolton, while a member of the Radiophysics Division of the Australian Commonwealth Scientific and Industrial Research Organization, was responsible for some of the pioneering discoveries in radio astronomy, notably of the existence of 'radio stars'. In 1947, he was the first to put an upper limit (8′ of arc) on the size of the previously reported source in Cygnus, to define its position with sufficient accuracy to be able to say it was in a region of the Galaxy distinguished by the absence of bright stars and nebulæ, and to point out that the radio noise from it was out of all proportion to the optical radiation. Soon after, in 1948, he announced the position of other point sources; made the first identification with an optical object—that in Taurus with the Crab Nebula, the remains of an old supernova; and took some of the first steps in using the radio observations to throw new light on the structure of the Galaxy. With this background, it is not surprising that the research programme of the new Radio Observatory will be concerned principally with studies of radio stars. The main instrument will be an interferometer consisting of two steerable parabolic reflectors, each 90 ft. in diameter and having a mesh covering suitable for use down to 3 cm. The reflectors are each mounted on bogies on 35-ft. gauge railway tracks running north–south and east–west, so that when the pair is used as an interferometer the spacing and orientation can be varied.

The Institution of Electrical Engineers : Mr. C. W. Speirs

MR. CHARLES W. SPEIRS has been elected to honorary membership of the Institution in recognition of his contributions to the advancement of electrical science and engineering, and of his outstanding support for the work of the Institution, particularly of its Incorporated Benevolent Fund. Mr. Speirs studied at the University of Durham and in 1891 entered the works of Messrs. C. A. Parsons and Co. at Heaton as an engineering apprentice. In 1898 he joined the Morgan Crucible Co., Ltd., as engineer and technical adviser, remaining with that organization until his retirement in 1933. In 1944 Mr. Speirs made a substantial gift of land from his estate at Malden, accompanied by a notable endowment, to the Incorporated Benevolent Fund. These gifts, supplemented by the contributions of members to the 'Homes Fund', brought into being the residential estate for beneficiaries of the Fund known as the Chesters Estate.

Signor Luigi Emanueli : Faraday Medallist

SIGNOR LUIGI EMANUELI (who, we regret to announce, died on February 17) has been awarded the thirty-seventh Faraday Medal of the Institution of Electrical Engineers for his outstanding contribution of inventions and new applications in the field of electrical cables, and particularly for the invention of the oil-filled cable. Signor Emanueli, who was born in Milan in 1883, graduated in electrical engineering from the Milan Polytechnic in 1906. He is vice-president of the Pirelli Company of Milan, where he started his professional life in 1907. He was elected a member of the Institution of Electrical Engineers in 1922. Signor Emanueli has been connected with numerous scientific inventions and applications in the electrical cable and the rubber industries including the oil-filled cable, universally known as the Emanueli cable, which represents a turning point in technical progress in this field.

Increased Grants for Universities in Britain

IN a written answer in the House of Commons on February 9, the Chancellor of the Exchequer, Mr. D. H. Amory, said that the University Grants Committee has recommended that in consequence of unexpected increases in student members and also increases in costs, the recurrent grants to universities in Britain for the last three years of the quinquennium should be increased. Existing grants were fixed on the expectation that by 1961–62 the number of full-time students would rise to about 102,000. In the current academic year this estimate would be exceeded by at least 6,500 and by the end of the quinquennium the increase was likely to be even greater. Mr. Amory said he is satisfied that some further assistance should be given to the universities and stated that he proposed to ask Parliament to provide for an increase of £2,550,000 in the recurrent grants for 1959–60, £2,660,000 for 1960–61 and £2,720,000 for 1961–62, exclusive of the provision required to meet the improved salary scales announced on March 12, 1957.

Research on Fuel and Power in Britain

THE Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, replied in the House of Commons on Monday, February 9, to a series of questions about fuel and power research. He said that the Scientific Advisory Council of the Ministry of Power is concerned with the co-ordination and development of research in the utilization of the fuel resources of Britain. The Council works under an independent chairman and includes representatives of the fuel and power industries, the Department of Scientific and Industrial Research, industry generally and the universities. Experimental work with liquid methane is being paid for by the British gas industry and the American interests concerned, and the total cost to the gas industry is estimated at £1·5 million. The National Coal Board has decided to terminate experimental work on underground gasification at Newman Spinney on the ground that present results do not justify further expenditure. Research on the production of gas from oil is being concentrated upon hydrogenation of oil, and a commercial plant to work initially on oil and later on coal has been commissioned by the Gas Council. The gas industry estimates that its consumption of tail gas and other refinery surpluses may increase, in terms of coal equivalent, from the present 500,000 tons to 2 million tons in 1965.

The Tropical Products Institute

THE Tropical Products Institute is to become one of the research stations of the Department of Scientific and Industrial Research, following the decision to transfer the responsibility for the Institute from the Secretary of State for the Colonies to the Lord President of the Council, so that Commonwealth countries which have recently achieved independence, and thus no longer come within the scope of the Colonial Office, may still avail themselves of the services of the Institute. Support will continue to be provided by the Colonial Office, from the Colonial Development and Welfare Funds, for work of primary interest to the Colonies. The main objective of the Tropical Products Institute is to ensure the economic viability of the under-developed territories of the Commonwealth within the tropics, by improving the technology of industries that already exist and introducing new industries as a result of research into new uses for tropical plant and animal products (including waste products of existing industries). Particular attention will be directed to the needs for diversification in those territories which have a one-crop economy.

New European Nuclear Energy Project

THE third international project in the programme of the European Nuclear Energy Agency for the development of nuclear power for peaceful purposes on a European basis has been approved by the Agency's Steering Committee. Six European countries, together with Euratom, will combine in a joint investigation of the use of high-temperature gas-cooled reactors for nuclear power stations and other applications. The new project, known as *Dragon*, will be based mainly on the construction of an experimental power-producing reactor, developing several megawatts, at the United Kingdom Atomic Energy Authority's Research Establishment at Winfrith Heath in Dorset. The cost of the five-year programme of research and experiment is estimated at some £13·6 million. £10 million will be provided by the United Kingdom, Euratom (43·40 per cent each), Austria, Denmark, Norway, Sweden and Switzerland. The excess £3·6 million will be borne by the United Kingdom, which will retain ownership of the reactor and installations on conclusion of the *Dragon* project. The agreement inaugurating the project is expected to be signed at the Organization for European Economic Co-operation headquarters in Paris. Previous joint nuclear energy undertakings initiated by the European Nuclear Energy Agency comprise a twelve-country Convention setting up the European Company for the Chemical Processing of Irradiated Fuels (Eurochemie) with plant and laboratories under construction at Mol in Belgium; and a Boiling Heavy Water Reactor at Halden in Norway, in the operation of which five Organization member countries and the Euratom Commission are participating.

New Reactor to be Built at Windscale

A NEW low-power research reactor is to be built at Windscale, which is being expanded as one of the national centres for the development of gas-cooled reactors. The new reactor, to be known as *Hero* (hot experimental reactor of zero power), will cost about £1¼ million and will be built near the advanced gas-cooled reactor (*Agr*), on which work has already started. Its function will be to complement the work of *Agr* by making it possible to carry out measurements at low radiation-levels and to experiment with several alternative arrangements of fuel to obtain the best results. It will be completed early in 1961 and will be operated and studied by physicists of the Research and Development Branch of the United Kingdom Atomic Energy Authority at the Windscale laboratories. *Hero*, which will generate a few kilowatts of heat, will consist initially of a graphite structure 19 ft. in diameter and 19 ft. high, but an important feature is that it will be possible to dismantle it and rebuild it in a variety of ways. The graphite core will be contained in a steel vessel connected to a pipe circuit with pumps and heaters so that it can be operated at high temperature in carbon dioxide. It will, in fact, be the reverse of *Agr*, since the carbon dioxide gas will supply heat to the core instead of removing heat from it. The fuel will consist (as in *Agr*) of clusters of rods of uranium oxide sealed into beryllium cans, arranged in channels in the graphite in a regular lattice.

Advanced Gas-cooled Reactor Power Stations

IT is expected that from about 1965 onwards the reactors for nuclear power stations in Britain will be based on *Agr*, using uranium oxide fuel and beryllium instead of magnesium cans. This will permit higher operating temperatures and heat ratings and consequently will lead to greater efficiencies than can be achieved in the reactors now being built for the electricity authorities. The levels of radiation inside the reactors will be considerably higher. Two broad categories of problems are raised by these more severe conditions: those of reactor physics and those of reactor materials. The most important material problem is to develop fuel elements which can withstand high burn-up under the exacting conditions of high temperature and high flux, and the main purpose of the *Agr* prototype is to test various types of fuel at high power for prolonged periods (100,000 kW. of heat). It is essentially a fuel-element development reactor. The reactor-physics problems concern the behaviour of neutrons within the reactor. The high radiation-levels necessary in *Agr* for fuel testing and power production prevent the physicist from gaining access to the parts of the reactor which need most careful study. Sensitive techniques, however, are available with which it will be possible to carry out the necessary measurements at low radiation-levels in *Hero*. In addition, there are the problems of the kinetics and stability of highly rated reactors. *Agr* fuel is intended to remain in the reactor for a long time, building up very substantial amounts of plutonium. The reactivity of such a system is strongly dependent both on the fuel and moderator temperatures and on the isotopic content of the fuel, and careful study is therefore needed of the stability and control of such reactors.

Conservation Corps for Young Volunteers

ONE important purpose of the Council for Nature is to assist in the conservation of areas important to naturalists and country-lovers. The Council for Nature has embarked on a new venture and has started to organize a Conservation Corps for young volunteers. The volunteers will combine a holiday of manual work on a site needing attention with study of the natural history of the area under expert guidance. This scheme will achieve two ends: the education of young people in the principles of nature conservation, thus establishing a pool of future leaders for further studies in natural history; and the restoration and preservation of areas of special interest for future generations. This plan will require expenditure over the next five years of £25,000, and towards this the Carnegie United Kingdom Trust is making a provisional grant of £9,000 to be spread over the first three years. The response from other sources, particularly the larger industrial firms, has been encouraging and the Council is confident that the project will develop in its entirety. The Council has appointed as organizer of the Conservation Corps Brig. E. F. E. Armstrong, a retired officer of the Royal Engineers. His last Army appointment was concerned with the selection of young men and women for regular commissions, and since leaving the Army he has been warden at the Loughborough College of Technology. He has had considerable experience in the Boy Scout movement and Toc H and is also a keen naturalist.

Regiomontanus's Astrolabe at the National Maritime Museum

THE National Maritime Museum has recently placed on exhibition a small brass astrolabe made in 1462 by Johannes Muller, of Königsberg, known to posterity by his Latin name, Regiomontanus. This astrolabe was the first scientific instrument he made—it was a gift to his patron, Cardinal Bessarion, who had brought the young scholar to Rome from Nuremberg and given him access to his fine manuscripts on classical Greek astronomy. Later, Regiomontanus returned to Nuremberg and erected there an observatory, a press for printing scientific books and a workshop for making scientific instruments. It is this activity, spreading out from his centre, that marked the rebirth of astronomy and the beginning of the Renaissance of science. The astrolabe is a circular star map that can be rotated so as to calculate the positions of the Sun and the stars at any time of any day of the year; it could also be used for simple observations. The style of the instrument and its special arrangement of star pointers were copied by later workers, and the exquisite craftsmanship pointed clearly the way of later precision instruments. The instrument was presented to Dr. William Somerville (husband of Mary Somerville, after whom Somerville Hall, Oxford, was named) in Rome; he gave it to his friend, Sir John Herschel. It has remained in the Herschel family ever since and has now been lent to the Museum by Commander M. H. Hardcastle, R.N.

Council of Europe Competition in Advanced European Research

A prize of one million French francs is to be awarded every two years by the Secretariat-General of the Council of Europe for an original thesis of high academic standard on a given subject of European importance. It must not have been previously published, and must represent an original contribution on the subject set. The subject chosen for the first competition is "Consequences of the Use of Nuclear Energy for the European Mode of Life". Theses may be written in English, Dutch, French, German, Italian or Spanish, and entries must be submitted before the end of 1960. A jury, chosen by the Secretariat-General on the advice of the Committee of Cultural Experts of the Council of Europe, will award the prize. Further information can be obtained from the Secretariat-General, Council of Europe, Strasbourg, France.

Support for Institutes for Advanced Study in Science

The North Atlantic Treaty Organization has established a fund to provide financial assistance to institutes and summer schools for advanced scientific study in those cases where a large degree of international participation is anticipated among both the faculty and the students. No precise pattern has been defined for eligible institutes, but it is expected that the programmes will normally last between two weeks and two months, will be at a postgraduate or higher level, and will provide for concentrated study of a restricted scientific field. It is hoped that this fund will encourage the establishment of institutes for advanced study similar to the highly successful summer schools of theoretical physics at Les Houches and Varenna, but in other scientific fields. Institutes and summer schools for advanced study in any of the natural sciences or technology may appropriately apply for grants. Although the eligible institutes must be situated in one of the fifteen member nations of the North Atlantic Treaty Organization, no nationality or other restrictions for either the staff or the students are in any way implied. Further information on the programme can be obtained from the Science Adviser, NATO Headquarters, Palais de Chaillot, Paris XVI, to whom applications for grants should be made.

Reform of the Calendar

A brief review of the history of the calendar by Y. G. Perel (*Priroda*, 7, 47; 1958) suggests the urgent desirability of establishing a world calendar, such as was proposed by India in 1953 before the United Nations. According to this proposal, the year will be divided into four quarters of thirteen weeks each, with the first month of thirty-one days and the following two of thirty days each. An additional day (the day of peace and friendship) is added after December 30, and on leap years an additional day after June 30.

The Rockefeller Institute Press

The Rockefeller Institute Press has been established to publish books on science and related subjects in association with the Oxford University Press, New York. Editorial responsibility for the books will rest primarily with the Institute, while Oxford will be chiefly responsible for design, printing and distribution. It is expected that the first books will be issued in the autumn of 1959. While many of the books and monographs will be the work of Institute faculty members, works by others will also be published. The Rockefeller Institute Press will be under the direction of Charles I. Campbell, administrative associate for information services at the Institute.

Lapis

Lapis, a monthly journal of industrial opportunities, the first number of which appeared in October 1958 (pp. 28. Subscription rates, including postage for one year: inland, £10 10*s*. 0*d*.; abroad, U.S.A. and Canada, 30 dollars; France, 15,000 francs; Italy, 19,000 lire. London: Kenneth Mason, 1 Old Burlington Street, W.1), lists patents available for disposal by licence or sale. These are classified in two parts: general, mechanical and electrical; and chemistry and chemical engineering. There is also a list of agents and agencies wanted. Details of patents for disposal and partnerships for development are sought from all over the world.

National Museum of Wales

The annual report of the National Museum of Wales for 1957–58, after giving details of the personnel of Court, Council and staff, records that the third application to the Treasury for permission to establish a Department of Industry was granted. A sum of £2,000 was provided for this purpose. To supplement this an appeal for £5,000 has been addressed to local industrialists. The keeper of geology, Dr. F. J. North, acted as keeper of the new Department, and in addition to arranging a typical exhibit illustrating the development of the miners' safety lamp, was able to establish some useful contacts for the future. An impressive series of seventeen temporary exhibitions was arranged during the year. In the Department of Geology the emphasis has been on the reserve and study collections, while the chief task of the Department of Botany was to organize an exhibition illustrating paper and its uses. In the Glanely Gallery three cases, "Animals without Backbones", "Butterflies and Moths" and "The Main Group of Insects", were entirely re-arranged, while in the Department of Archæology reorganization has continued. In the Department of Art displays of Sheffield plate, the regalia of the Gorsedd of Wales have been added and other exhibits enlarged. The Welsh Folk Museum was chiefly concerned during the year with the re-erection of three houses from Cilewent, Radnorshire; Hendre'r-Wydd, Denbighshire; and Llandfadyn, Caernarvonshire. Such a record of progress in all Departments is a measure of the devotion of the staff of this Museum to the interests of the community.

1959 Waverley Gold Medal Competition

The Waverley Gold Medal and a prize of £100 will be awarded for an essay of about 3,000 words based on recent scientific research or development (whether the author's work or not), giving an outline of the scientific background, the experimental results and its potential application in industry. Essays will be judged for technical content, clarity of presentation and for style. A second prize of £50 will also be awarded; and an additional prize of £50 is offered for the best entry from a competitor under the age of thirty on July 31, 1959. The competition is open only to persons engaged in scientific work during January 1–July 31, 1959. Further details can be obtained from the Editor, *Research*, 4/5 Bell Yard, London, W.C.2, to whom all entries must be submitted before July 31.

Bell Telephone Laboratories: Kelly Award

Bell Telephone Laboratories and the American Institute of Electrical Engineers have announced the establishment of an award for achievement in the field of telecommunications, to be known as the Mervin J. Kelly Award. The award is named in honour of Dr. Kelly, formerly president and now chairman of the board of Bell Laboratories, who will retire on March 1 after forty-one years of scientific and administrative service with the Bell Telephone System (*Nature*, 183, 221; 1959). The Kelly Award will be given annually by the American Institute of Electrical Engineers to an individual who has made an outstanding contribution to the advancement of telecommunications. The prize will consist of a bronze medal, a cash award of 1,000 dollars and a certificate. The first award will be made in 1960. The Award is being sponsored by Bell Laboratories but will be administered solely by the Institute.

"Electrode Potentials and Compound Formation in the Palladium–Platinum–Hydrogen System"

Referring to the communication under this title in *Nature* of January 3, p. 39, Messrs. A. W. Carson, T. B. Flanagan and F. A. Lewis write: "The platinum content of the palladium–platinum alloys investigated should be read as weight per cent. It had previously been reported (Stetsenko, A. I., and Tverdovskii, I. P., *Zhur Fiz. Khim.*, 26, 647; 1952) that the upper limit of platinum content in palladium–platinum alloys, which allows of the formation of a two-phase region close to 25° C. in the palladium–platinum–hydrogen system, is about 9 per cent by weight platinum and not 5 per cent as incorrectly quoted by us".

Burden Neurological Institute: Dr. W. Ross Ashby

Referring to the note on the appointment of Dr. Ross Ashby as director of the Burden Neurological Institute, Bristol (*Nature*, January 24, p. 220), it has been pointed out to us that he will not be succeeding the retiring director, Prof. F. L. Golla, until May 1. Dr. Ross Ashby was referred to as "previously director of the Research Laboratory at Barnwood House, Gloucester"; he is in fact director of research at that Institute. For eleven years Dr. Ross Ashby was pathologist at St. Andrew's Hospital, Northampton. Among his publications is "An Introduction to Cybernetics", which has been translated into French, Spanish and Russian. In 1932 he obtained the Bronze Medal and Prize of the Royal Medico-Psychological Association, and in 1948 he obtained the Burlingame Prize (£100) offered by the Institute of Living, Hartford, Connecticut, for the best piece of original research carried out during the previous year. In 1956 he was granted a fellowship at the Center for Advanced Study in the Behavioral Sciences, Stanford, California.

Announcements

Prof. R. O. Redman, director of the Observatories in the University of Cambridge, has been elected president, for 1959–60, of the Royal Astronomical Society, in succession to Dr. W. H. Steavenson.

The Secretary of the United States Army, Mr. W. M. Brucker, has presented a replica of *Explorer* 1, the first American Earth satellite placed in orbit, together with its *Jupiter-C* carrier rocket, to the Smithsonian Institution.

Arrangements have been made by the British Council with the assistance of the Foreign Office, the Board of Trade and the Nuclear Energy Consortia for Prof. W. Murgatroyd, professor of nuclear engineering in Queen Mary College, London, to visit Venezuela, Colombia, Peru and Mexico during March 30–April 29. Under similar arrangements Prof. J. M. Kay, professor of nuclear power in the Imperial College of Science and Technology, London, is to visit Chile, Argentine, Uruguay and Brazil during March 23–April 29. They will lecture to scientists and engineers on British nuclear developments and aims, and also discuss the possibilities for future co-operation with the United Kingdom.

The Proceedings of the Fourth International Congress of Biochemistry, held in Vienna in 1958, are being published by the Pergamon Press by arrangement with the International Union of Biochemistry. The fifteen volumes include all the contributions, invited discussions, symposia and colloquia presented.

A debate, organized jointly by the Royal Institute of Chemistry (London Section), the Classical Association (London Branch) and the Haldane Society, on the motion "That the Education of our Future Rulers should be primarily in the Sciences rather than in the Humanities", is to be held in the Beveridge Hall, Senate House, University of London, on March 18. The chairman will be Sir Cyril Hinshelwood; for the motion, Sir Alexander Fleck and Prof. A. R. Ubbelohde; against the motion, Prof. B. Farrington and Prof. W. Beare.

The Plant Phenolics Group is holding a symposium on "Phenolics in Plants in Health and Disease" in the Department of Engineering in the University of Bristol on April 2 and 3. Further details can be obtained from the honorary secretary, Dr. T. Swain, Low Temperature Research Station, Downing Street, Cambridge.

The annual International Starch Convention organized by the German Cereal Research Station at Detmold is to be held in Detmold during April 21–23. It will be followed on April 24 by a special Convention to celebrate 75 years of potato research and also on April 24 and 25 there will be held at Detmold the first plenary session of the newly formed International Committee for the Standardization of Analysis of Starch and its By-products. Further information can be obtained from Dr. Eric Dux, Sichel Adhesives, Ltd., 6 Friar's Lane, Richmond, Surrey.

FUEL AND POWER IN BRITAIN

A DEBATE in the House of Lords on January 21 on fuel and power policy in Britain was opened by Viscount Hall, who questioned the policy of replacing the use of coal by oil, particularly at four of the new nuclear power stations, and also suggested that the nuclear power policy might need revision in view of the rate of development and the possibility of building stations that would rapidly be outdated. Replying for the Government, the Minister of Power, Lord Mills, said that current government policy is following the general lines endorsed by the Ridley Committee. He stressed the importance of the Scottish Gas Board's decision to construct a Lurgi plant in Fife for the total gasification of poor-quality coal; this has arisen from close co-operation between the National Coal Board and the gas industry. A similar plant is to be constructed by the West Midlands Gas Board to use deep-mined coal of poor quality, and as an outcome of co-operation between the refineries and the gas industry, surplus products from refineries are to be delivered to gas works and processed into town's gas. Coal still provides the bulk of the fuel requirements of Britain—more than 200 million tons a year—and he hoped that research and development will in due course create new demands for our indigenous coal resources. The Scientific Advisory Council of the Ministry, under the leadership of Sir Alexander Fleck, has been asked to study these possibilities.

In view of the present excess of supply over demand for coal in Britain, the Government has been strongly urged to reduce further the production of opencast coal, to restrict the increasing use of oil fuel and to scale down the nuclear energy programme. Lord Mills stressed the temporary character of the present shortage. As regards opencast coal production, the output is to be reduced by 3 million tons this year; further reduction would involve breaking contracts with an industry in which £27 million has been invested in plant for this purpose. The Government, however, does not agree that the use of oil, which now represents 15 per cent of the fuel consumption of Britain compared with 7 per cent before the War, should be restricted. This would be inconsistent both with the fuel policy of the country and with the Government's general policy of removing restrictions on international trade. The liquid methane imports mentioned by Lord Hall represent, he said, an experimental trial of the technical and economic possibilities. As regards nuclear power, Lord Mills regretted the suggestion for curtailing the programme to increase the market for small coal. Cheap and abundant power is the basis of a thriving and progressive economy. Thanks to the work of scientists and engineers, Britain leads the world in the use of nuclear energy for the generation of electricity, but we could only utilize that lead by developing an industry continuously advancing the applications of nuclear energy by designing and applying reactors and associated engineering works. This would lower capital and operating costs, to the ultimate benefit of users of electricity and, although great improvements had been made in power stations operated by coal, we should reach a stage when the cost of nuclear power would justify our programme. Any practical results from the fast breeder reactor, of the type being constructed at Dounreay, were probably 10–15 years away, and from *Zeta* still further, but they are all promising developments.

Production of phurnacite has increased to 600,000 tons a year, but there have been setbacks in the development of full-scale manufacture of the process for binding anthracite known as shape. The Coal Board is now completing a pilot installation for the underground gasification of coal at Newman Spinney, near Chesterfield, and it was hoped that gas from this installation would shortly be generating electricity in a small temporary power station erected there by the Central Electricity Board. The programme of the Board for 1958–63 would provide new installed capacity of 12,800 megawatts, of which 10,730 megawatts will be steam driven, including seventeen new stations and three extensions to consume 25–30 million tons of coal a year when in operation.

On the matter of costs the Paymaster-General, Mr. R. Maudling, said in the House of Commons, on the second reading of the Electricity (Borrowing Powers) Bill on January 20, that while the capital cost of nuclear power stations at Bradwell and Berkeley will be about three times that of a coal-fired station, that of Hinkley Point will be down to 2·5 times. The present calculation is that the Hinkley Point station, of which the capital cost will be £120 a kilowatt, as against £145 for the earlier stations, will be marginally slightly more economic than a coal-fired station operating in the same area. Assuming 5 per cent interest-rate, 20 years life for the plant and a 75 per cent load factor, he believes that by the earlier 'sixties the nuclear plant will be marginally more economical than conventional plant.

SECONDARY EDUCATION IN BRITAIN

THE Government White Paper, "Secondary Education for All: a New Drive"*, marks no real change of policy but gives some welcome assurance of continuity. The imminent but temporary decline in the school population is to be utilized to improve the quality of education, and the bulk of the new expenditure is to be concentrated on the secondary schools. By the mid-1960's the worst inadequacies of the schools will have been remedied. There will be more and better school buildings; more and better trained teachers; and smaller classes. The Government, however, considers it would be wrong to dissipate the improvement in educational standards to be secured under this immediate five-year programme by attempting too much too soon. The main objective is to encourage those young people who wish to stay on voluntarily at school beyond the minimum school-leaving age and there is nothing in the White Paper about fixing dates for measures to extend the compulsory period of education. The programme is part of a concerted drive to create an educational system adequate to meet both national and individual needs in the modern world. The keynote is opportunity for the individual boy or girl to go as far as his or her keenness or ability will allow, and the nation must grasp the opportunity to develop the educational system so that it can better fulfil its task of producing citizens who are fitted by character, knowledge and skill to play their full part in an increasingly educated and responsible democratic society.

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* Secondary Education for All: a New Drive. Pp. 10. (Cmnd. 604.) (London: H.M. Stationery Office, 1958.) 9*d*. net.

Before outlining the specific programme, the White Paper points out that the Government does not wish to rule out experiments with comprehensive or similar schools proposed on genuine educational grounds, but is convinced that it would be wrong to abandon the grammar schools, though they alone cannot provide sufficient numbers of highly trained citizens. There is still plenty of room for experiment in the precise pattern of organization to be adopted. The widest possible range of opportunities should be provided for boys and girls of different capacities and fitness, but it is wrong to think that each school can do everything or that each type of school must have a fixed and self-contained exclusive territory.

As a first step the Government proposes to launch and carry through a continuous building programme for primary and secondary schools, rising from £55 million in 1960–61 to about £60 million in 1961–62 and costing £300 million in the five years to 1964–65. An immediate increase is being made in the volume of minor works which local education authorities and school governors can undertake, and the limit of cost is being raised from £10,000 to £20,000. The reorganization of the remaining 'all-age schools' in which are more than 150,000 pupils of eleven or more is to be completed, and resources will also be found for improving conditions in existing secondary schools. Reference is made to the improvement of science facilities, and although it is not expected to bring all secondary school buildings up to modern standards, by concentrating first on the tasks that will most quickly yield improvements it is hoped to make a big advance towards secondary education for all within the five-year programme. As regards the reduction in the size of classes, the Government's policy is first to increase the supply of teachers, and apart from the expansion of teacher training colleges already announced the Government's policy is to increase recruitment from universities also as far as is consistent with the maintenance and improvement of quality. It is determined that the size of primary classes should continue to be reduced as quickly as possible so that classes of more than forty children are virtually eliminated by the middle-1960's. A decisive general improvement in secondary school classes is also expected within the next five years. The White Paper includes a useful summary of progress under the Education Act of 1944.

THE COUNCIL FOR SCIENCE AND TECHNOLOGY OF WESTERN GERMANY

AN important event during the past year was the foundation of the *Wissenschaftrat* (Council for Science and Technology) in Western Germany. It was constituted on February 8 with the Federal President himself taking the chair, following a proposal by the president of the German Research Association (*D.F.G.*), Prof. Hess. Previously, at its annual general meeting, the Industrial Donors' Association had already welcomed the idea and stood squarely behind it from the outset. The tasks of this new body are as interesting from a purely practical as they are from an idealistic point of view. Just as interesting is its composition, reflecting all sections of academic, public and industrial life, with members who may be expected to take a large and important share in research, university teaching and training, and the application of pure and applied research in industry and commerce. The academic element, as is traditional in Germany in such matters, is in the majority—sixteen professors, all prominent nominees of the German Research Association, the Max Planck Society and the Committee of German Vice-Chancellors (*Rektorenkonferenz*). In addition to this academic core, the Federal and Land Governments delegate jointly six members, and the Federal Government alone six further leading Civil servants. The latter represent the Ministries of the Interior, Finance, Economics, Food, Transport and include a Secretary of State from the Ministry for Atomic Energy and Waterpower. Also the *Länder*, the highest education authorities, including universities, are themselves represented at ministerial level, by one delegate each, including Berlin, thus adding nine members. This adds up to thirty-seven, to which the industrialists as sponsors and donors (*Stifterverband für die deutsche Wissenschaft*) also send their honorary president and curator and six further members.

These forty-five men forming the new Council are thus a significant mixture of prominent personalities and well qualified, it would seem, to deal with their brief. This was summarized in the *Bulletin Wirtschaft and Wissenschaft*, published in the spring of 1958:

(1) The reflexion to the outside world of the unity and equality of all science, that is, of the equal importance of research, teaching and training in Germany. This Council could be described as the 'scientific conscience of the nation'.

(2) The Council will have to assess and determine the total requirements of the three tasks, research, teaching, and training, covering the whole federal area.

(3) The Council has to hold a watching brief over a proper flow of young men of promise from university institutions, industry, public life, into positions of responsibility and leadership.

(4) Reforms and developments have to be taken care of, with regard to all three aspects mentioned above, and the financial implications to be worked out in collaboration with the Ministry of Finance.

(5) A key to apportioning financial liabilities among Federal and Land governments has to be found, possibly on a quinquennial basis. (The latter point recalls the five-year period in the fiscal commitments

of the Treasury in Britain, through the University Grants Committee, and it is not improbable that the German suggestion was influenced by the British example. There is ample evidence that the latter was carefully studied.)

(6) The Council will have to smooth out inequalities and co-ordinate measures taken by the central and local governments (*Länder*, cities and districts), as regards the promotion of interest in science and research.

(7) Finally, it will be the Council's duty to scrutinize a proposal to create a central agency for the promotion of science, scholarship and research, under a federal ministry.

This is only a brief statement of the main aims for which this Council was called into being. Conditions for its proper functioning will, of course, be :

(1) The provision of adequate grants for supra-regional research institutions and projects, from the central Government and the land authorities, inasmuch as the latter cannot adequately finance them.

(2) The willingness of *Länder* governments to supplement federal funds in financing certain regional institutions.

(3) The readiness of industrial and commercial organizations to give larger sums than hitherto for the general promotion of science and for scholarships, over and above those which benefit industry directly.

(4) Parliament will have to strengthen and support the Council by accepting its advice and legislating in the light of this advice. The Council should in time achieve considerable public importance, comparable to that of the University Grants Committee.

(5) Finally, the Council should devise broad reforms for staff–student relations in institutions of higher education, for only this can ensure the vigilance necessary for 'talent-spotting' in the future.

Perhaps the most important of these points is Parliament's job of budgeting for developments in science, scholarship and technology. The first step has already been taken : annual returns have been abandoned in favour of five-year plans. A carry-over of unspent funds must obviously be permissible. Altogether, a generous, non-bureaucratic attitude seems to have been emphasized from the outset, as befits a body composed of representatives drawn from so many sources.

All members of this new Council are aware that they have to make up a good deal of lost time and, for the sake of their country's great tradition in research and scholarship, they are anxious to regain a new leading place in international science.

J. Horne

PHOSPHATES AND ORGANIC SUBSTANCES IN NITROGEN DEFICIENCY

THE International Association for Research on Phosphates, with its headquarters at 28 rue Saint-Dominique, Paris VII^e, held its third congress at Biarritz during October 21–24. Approximately one hundred scientists and chemical engineers from twenty-three countries attended the Congress, which which was on the greater utilization of phosphates.

Communications on mining phosphate rocks, their solubility, residual effects in soils, influence in plant growth and value when incorporated with organic substances were read and discussed.

Drs. L. Schmitt (Darmstadt, president of the Association), F. Van der Paauw (Gröningen), F. Scheffer (Göttingen), L. Gisiger (Liebefeld, Switzerland), Ed. Hofman (Weihenstephan, Germany), L. Wiklander (Uppsala) and G. Barbier (Versailles) considered different aspects of the solubility of natural rock phosphates when added to soils and the phosphates present in soils under various conditions.

Drs. J. Cuzin (Paris, secretary of the Association), A. Fardy (Athens), Mme. Bireska (Warsaw), Drs. S. Nicolic (Belgrade), K. Nehring (Rostock) and M. Homes (Brussels) presented their observations on drop growth fertilized by different sparingly soluble calcium phosphates and phosphate rocks. Dr. O. Arrhenius (Grödinge, Sweden) reported a favourable effect on growth of trees when fertilized by powdered rock phosphates at the rate of one kgm. per tree.

All over the world there is a tendency towards a greater utilization of basic slag, phosphate rocks and strongly heated phosphate rocks instead of superphosphate and other soluble phosphates. This is certainly good for permanent agriculture, because the basic calcium phosphates leave a greater residual effect in soils and decrease the leaching of lime from the land. Dr. G. W. Cooke (Rothamsted) reported a more marked gain in the phosphate status of land when treated with bone meal than when superphosphate was utilized in the Saxmundham experiments over fifty-six years. It is of interest to note in this connexion that Dr. S. Nordengren (Landskrona, Sweden), the leader of the superphosphate industry in Sweden, is considering the manufacture of under-acidulated superphosphate and triple superphosphates for the market.

Interesting experiments on the solubilization of rock phosphates by the action of soil micro-organisms were described by Drs. L. Meyer and Eva Köning (Hohenheim-Stuttgart) and Dr. J. Pochon and Mlle. A. Roche (Pasteur Institute, Paris).

Dr. N. R. Dhar (Allahabad) discussed the augmentation of atmospheric nitrogen fixation in soils by incorporating different phosphates, with organic substances like green manure, farmyard manure, straw, municipal waste, leaves, grass sods, sawdust, legumes, or finely divided coal dust ploughed into the soil. He also reported that when basic slags, phosphate rocks or superphosphates are added to these organic substances during the process of composting, there is more fixation of atmospheric nitrogen in light than in the dark, and that the total nitrogen contents of the phosphated composts vary from 1·6 to 2·4 per cent as against 0·6–1 per cent present in the Indore composts of Howard. In this connexion it is interesting to record that Dr. L. Borasio (Vercelli, Italy) obtained good results in rice cultivation with a mixture of powdered rock phosphate and farmyard manure. Similar observations were described by Drs. E. Bottini (Turin) and A. Zeller (Vienna).

Recently the Soil Association at Haughley (England) obtained a yield of 30·4 cwt. of barley grain per acre by ploughing in 99 lb. phosphate per acre as basic slag mixed with barley straw. The yield with 112 lb. nitrogen as ammonium sulphate added to the same amount of straw was 20·8 cwt. per acre and in the control field containing only straw the yield was 14 cwt. per acre.

That phosphates and organic matter can fix atmospheric nitrogen in the soil and supply available nitrogen, phosphate, potash, humus and trace elements is of supreme importance in meeting the nitrogen shortage in the world (see *Nature*, **164**, 597 ; 1949).

The food production in the world is estimated to be approximately 1,100 million tons, for feeding the 2,700 million people. Out of this food, about 650 million tons consist of cereals (producing 1,100 million tons of straw containing 7–8 million tons of nitrogen) and 450 million tons of other foodstuffs. As only 25 per cent of the added nitrogenous fertilizers and manures is normally recovered in crops, and the average nitrogen content of the food materials is 2 per cent, approximately 110 million tons of fixed nitrogen seem to be necessary for the food production of the world. But chemical industry is supplying only 7 million tons per year (Table 1).

Table 1. WORLD PRODUCTION AND CONSUMPTION OF FERTILIZERS, 1955–56

Region	Production (1,000 tons)			Consumption (1,000 tons)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Western Europe	2774·8	3352·0	3055·9	2248·9	3112·9	2639·9
United States	2033·0	2252·0	1735·0	1714·4	1989·3	1677·1
Eastern Europe	1222·7	1341·8	2113·0	1263·8	1405·9	1502·4
Far East	843·2	402·1	—	1145·0	411·9	428·3
Elsewhere	513·9	1096·5	12·1	591·2	1230·2	422·3
World total	7387·6	8444·4	6969·3	6969·3	8150·2	6670·0

It has been estimated that 4,000 million acres of land are available for cultivation in the world, and of this only 1,000 million acres are considered as first-class land. Consequently, if the fertilizers consumed in the world were evenly applied to the 4,000 million acres, each acre of land would receive 3·5 lb. nitrogen, 4·05 lb. phosphorus pentoxide and 3·3 lb. potassium oxide per year. It is an interesting coincidence that the fertilizers consumed in the United States per acre in 1956–57 are of the same order, that is, 4·2, 4·6 and 4·0 lb., respectively. Evidently these amounts are inadequate for intensive cultivation.

Moreover, the industrially under-developed countries find it difficult to construct nitrogen fixation factories. Table 2 shows the capital cost involved in the different types of ammonia synthesis plants for manufacturing 100 tons of ammonia per day.

Table 2. CAPITAL INVESTMENT (DOLLARS) FOR DIFFERENT TYPES OF AMMONIA SYNTHESIS PLANTS

Natural gas	Fuel oil	Coal	Coke oven gas	Catalytic reformer gas
3,950,000	4,098,000	4,248,000	3,620,000	2,980,000

In a study on "Observations on the Planned Provision of Nitrogen Fertilizer", Prof. Tinbergen and others of the Netherlands Economic Institute, Rotterdam, have reported that the world demand for nitrogen fertilizer in 1960–61 is expected to be 8·1 million tons (Europe, 3·1 million tons ; United States, 2·4 million tons ; other areas, 2·6 million tons). They also concluded that the consumption of nitrogen per acre of land is directly proportional to the population density of the country. This is shown in Table 3.

Table 3. NITROGEN CONSUMPTION IN 1956–57 IN KGM. PER HECTARE PER YEAR

Japan	109·6	Greece	12·1
Taiwan	86·7	Austria	11·5
Iceland	85·9	Portugal	10·5
Holland	79·0	Switzerland	10·1
Korea	54·1	Poland	10·0
Belgium	52·5	Spain	9·5
Norway	38·1	Philippines	5·6
West Germany	35·1	Czechoslovakia	5·0
East Germany	31·6	United States	4·2
Denmark	29·6	Ireland	3·2
Luxembourg	28·0	China	2·3
United Kingdom	23·5	Indonesia	2·0
Sweden	22·4	India	1·0
Ceylon	18·4	Turkey	0·4
Italy	14·7	Pakistan	0·3
France	14·4		

The average of the Organization for European Economic Co-operation area is 16·8 kgm. per hectare. It has been reported that there is shortage of chemical fertilizers in the U.S.S.R. The figures for nitrogen consumption in Table 3 show that, except in Japan, Taiwan, Belgium, Iceland and Holland, the nitrogen supply to crops as fertilizers is low. Only the countries having a large population density are compelled to use large amounts of industrial nitrogenous compounds, but not enough phosphates are used for producing the required amount of cereals. Moreover, in a recent publication (1957) on "Industrial Uses of Nitrogen" by the European Productivity Agency the following lines occur : "As world nitrogen production is outstripping the expansion of demand for traditional purposes (particularly for nitrogenous fertilizer), all producers are looking round for new outlets". It appears, therefore, that due to the high cost of nitrogenous fertilizers, farmers find it uneconomical to use the required amounts of chemical nitrogen for crop production.

The other nitrogen sources are legumes, precipitation, farmyard manure, municipal refuse and garbage. It has been reported that in the United States two million tons, and in the whole world five million tons, of nitrogen are fixed by the legumes in the soils of the Earth. Rain, snow and hail supply about 4–5 lb. per acre, that is, about 10 million tons of available nitrogen fall on the 4,000 million acres of agricultural land in the world, but a good deal is wasted as run-off. According to the U.S.A. Department of Agriculture, the world produces 1,400 million tons of manure containing 7–8 million tons of combined nitrogen, but only 15 per cent of this is actually utilized in cultivation. All over the world there is an attempt to prepare composts from city refuse and sewage sludge, which contain approximately 5 million tons of total nitrogen per year, but only a very small amount is actually reclaimed at present.

As the world reserves of phosphate rocks are not less than 21,000 million tons (United States, 7,000 million tons ; U.S.S.R., 6,500 million tons ; North Africa, 5,000 million tons ; other areas, 2,500 million tons) and the annual consumption has been estimated to be 30 million tons by R. Saint Guilhem, technical director-general of the North African Phosphate Company, the natural rock phosphates should, at the present rate of consumption, last for at least 700 years. Consequently, a much greater application of these phosphatic materials, and basic slag from the expanding world steel industry, mixed with organic waste, would be of great value to permanent agriculture in all parts of the world.

N. R. DHAR

MEASUREMENTS AT LEEDS FOLLOWING THE WINDSCALE REACTOR ACCIDENT

From the Department of Medical Physics, University of Leeds, The General Infirmary, Leeds, 1

Iodine-131 in Human Thyroids and Iodine-131 and Cæsium-137 in Milk

By Dr. P. R. J. BURCH

FOLLOWING the announcement of the Windscale reactor accident of October 10, 1957, an apparatus was assembled to measure the trace uptake of iodine-131 in human thyroids and the concentrations of iodine-131 and cæsium-137 in milk.

A 4-in. dia. × 2½-in. sodium iodide (thallium) crystal was optically coupled to a 5-in. diameter photomultiplier, the output from which was fed via a cathode-follower and a linear pulse-amplifier to an *MkI* 'Sunvic' pulse-analyser operated on its 60-channel range. The resolution obtained for the cæsium-137 photopeak was 14 per cent. Measurements were made inside a steel room, with walls and ceiling 9 in. thick, and a 12-in. thick floor, affording excellent attenuation of local γ-rays. The crystal-photomultiplier assembly was mounted on a bracket of adjustable height, and in the thyroid investigations the centre of the crystal was placed opposite the thyroid of the seated subject, so that the spacing between the crystal casing and the anterior skin surface over the thyroid was within the range of 1–2 in. Short separations were chosen to give the requisite high sensitivity, although this involved a sacrifice in calibration accuracy due to the uncertainties in the size and exact location of the thyroid. Calibration was performed at various separations with a mock thyroid, consisting of an iodine-131 solution in a glass bottle inserted in a wax 'neck' between the head and trunk of a water-filled 'phantom'.

Detailed γ-ray spectra over the energy-range 0·05–1·0 MeV. were taken in several cases, but due to the time-consuming nature of this operation it was not possible to employ it throughout, and in the remaining cases only the total count-rate for the energy-range 0·05–1·0 MeV. was recorded. Corrections for the contribution given by the cæsium-137 and potassium-40 contents of the body were deduced from detailed spectra. From experiments with a phantom, it was estimated that the count-rate from iodine-131 distributed through the body was less than 1 per cent of that from the thyroid, and consequently this small correction was ignored.

The results for the iodine-131 contents measured in human thyroids are summarized in Table 1 and the series of observations for subjects *A* and *B* are plotted in Fig. 1.

For the milk measurements, 1-pint bottles were clamped in a standard position against the end of the crystal casing, the axis of the bottle being at right angles to the crystal axis. Detailed γ-ray spectra were observed for a few samples, and corrections were derived for the potassium-40 contents of milk and bottle. The following response-rates for the energy-range 0·05–1·0 MeV. were determined: potassium-40 content of milk and bottle, 0·8 c.p.s.; 1·0 nc. (1 nc. = 10^{-9} curie) iodine-131, 3·6 c.p.s.; 1·0 nc. cæsium-137, 2·6 c.p.s. In the early samples the cæsium-137 contribution to the total counts was small compared with that from iodine-131 (Table 2); in the later samples, potassium-40 and cæsium-137 contributed, on the average, approximately 1 c.p.s. Where the cæsium-137 content was not directly determined from the detailed spectrum, the iodine-131 content was calculated by assuming that potassium-40 and cæsium-137 jointly contributed 1 c.p.s.

The milk results are summarized in Table 2, and the results for suppliers—one of the Leeds multiple dairies and the farm at Farsley—are plotted in Fig. 2. For the period October 16–25 the decrease of the iodine-131 content in milk samples from these suppliers was roughly exponential (there is evidently some alteration in the routine for milk delivered on a Saturday from the first suppliers) and the effective 'half-period' was approximately 3 days. Over the period October 26–November 13 the decrease in content was less rapid, the effective 'half-period' for samples from the above two suppliers being approximately 5·5 and 5·2 days, respectively.

The results are too few and too scattered for reliable generalizations concerning the iodine-131/cæsium-137 ratios in milk. The average for samples delivered on October 16 and 17 was 16 with extremes of 6 and 50. On November 6 and 7 this average ratio had fallen to 2·9. If the change in ratio had been due simply to the difference in physical decay of the two nuclides, the expected ratio on November 6 and 7 would have been 2·6.

This increase in cæsium-137 intake above that due to world-wide fall-out should have produced a significant increase in the body burden and this was, in fact, observed. In early 1957, the total body burden of cæsium-137 in subject *A* was 4·9 nc., but on April 1, 1958, this had risen to 11·5 nc. Assuming an effective half-life of 140 days[1] for

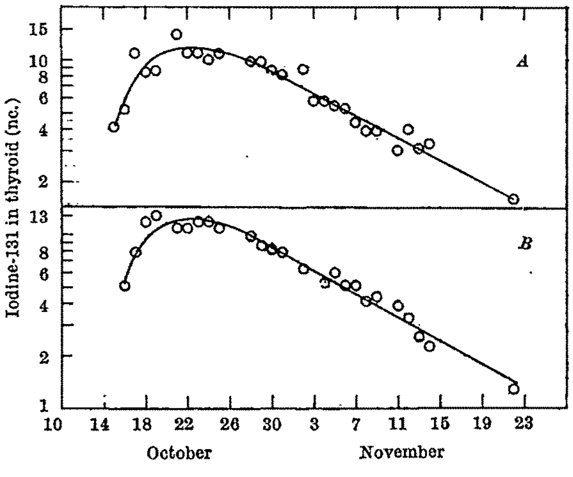

Fig. 1. Iodine-131 contents (nc.) of subjects *A* and *B* versus date

Table 1. Iodine-131 Content of Thyroid (in nc.)*

Date of measurement	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*
October 1957																				
15	4·1																			
16	5·2	5·1	26	3·3	4·8															
17	11	7·9				2·6	2·2	24	4·1											
18	8·4	12								2·7	3·0	3·9	9·0							
19	8·6	13																		
20														14						
21	14	11	26												16					
22	11	11																		
23	11	12														23				
24	10	12															2·7	2·2		
25	11	11																		
27														12						
28	9·8	9·8																		
29	9·8	8·6	21	9·3																
30	8·7	8·2											8·3							
31	8·2	7·9																		
November 1957																				
2	8·8	6·3												6·5					10	
3	5·8																			1
4	5·8	5·3																		
5	5·5	6·0																		
6	5·3	5·1																		
7	4·4	5·1																		
8	3·9	4·1																		
9	3·9	4·4																		
11	3·0	3·9																		
12	4·0	3·3																		
13	3·1	2·6																		
14	3·3	2·3																		
22	1·6	1·3																		
January 1958																				
10	0·02	0·02																		

* 1 nc. = 10^{-9} curie

A	Leeds resident. Intake of approximately 1·2 pt. *MA* milk daily.
B	Leeds resident. Intake of approximately 1·2 pt. *MA* milk daily.
C	Spent October 12, 13, 19 and 20 at Skipton (*MG* milk), remainder of time in Leeds.
D	Leeds resident. Some *MB* milk in tea but mostly *MC*.
E	Leeds resident. Approximately ¾ pt. *MB* milk daily.
F	October 11 Bristol, October 12 and 13 Surrey, October 14 p.m. Leeds, October 15 South Shields, October 16–17 Leeds.
G	London until p.m. October 16.
H	At Skipton with influenza until p.m. October 16. Milk from local farm.
I	Leeds resident. Approximately ¼ pt. milk daily.
J	Lake District. Keswick area until October 17 p.m.
K	Lake District. Keswick area until October 17 p.m.
L	Manchester resident. Milk from Chester area.
M	Ilkley resident. About ½ pt. *MF* milk daily.
N	Four-year-old Leeds boy. Approximately 1·2 pt. *MA* milk daily.
O	Cookridge, Leeds resident. Milk from local farm.
P	Leeds resident. About 1 pt. *ME* local farm milk daily.
Q	Polish visitor. Arrived Leeds October 22.
R	Polish visitor. Arrived Leeds October 22.
S	Leeds resident. Intake of approximately 1·2 pt. *MA* milk daily.
T	Resident in Cambridge until November 2 p.m.

For explanation of abbreviations see Table 2.

cæsium-137 in the body, it is estimated that there should have been an increase on this date of about 5 nc. due to the additional intake of cæsium-137 from the Windscale incident, through milk alone. Over the same period, the cæsium-137 body burden of subject *B* rose from 7·9 nc. to 19·5 nc.

Fig. 1, showing the initial rise and subsequent fall in the iodine-131 contents of the thyroids of subjects *A* and *B*, reveals clearly the connexion with the Windscale incident. Iodine-131 has been detected in human thyroids after nuclear weapon tests[2]; but the maximum uptake observed was of the order of

Table 2. Iodine-131 and Cæsium-137 in Milk. (Results in nc. per pint)*

Day delivery	*MA*		*MB*		*MC*		*MD*		*ME*		*MF*		*MG*	
	^{131}I	^{137}Cs	^{131}I	^{137}Cs	^{131}I	^{137}Cs	^{131}I	^{137}Cs	^{131}I	^{137}Cs	^{131}I	^{137}Cs	^{131}I	^{137}Cs
October 1957														
16	6·6	0·3	20·6	0·75	3·2	0·4								
17	5·0	0·1					6·3	1·0	11·5	0·8	12			
18	4·4													
19	7·4		6·4	0·55										
20	1·7													
21	1·9								4·4				10·8	
22	1·3								3·1					
23	1·9								2·8					
24	1·4								2·3					
25									2·4					
26	3·4													
27	0·9													
28	0·8								2·0					
29	0·6								1·5					
30														
November 1957														
2	0·34													
3	0·33													
4	0·39													
5	0·40													
6	0·27	0·08												
7	0·22	0·09												
8	0·37													
13									0·18	0·1				
18									0·05	0·08				

* nc. = 10^{-9} curie. *MA*, a Leeds multiple dairy; *MB*, a Leeds multiple dairy; *MC*, farm, Cookridge, Leeds; *MD*, farm, Menston, Leeds; *ME*, farm, Farsley, Leeds; *MF*, farm, Ilkley; *MG*, farm, near Skipton.

10^{-10} c., in contrast with the maximum uptake of the order of 10^{-8} c. reported here.

Where the intake of iodine-131 from milk can be estimated, a close association with the uptake of iodine-131 in the thyroid is observed. It is interesting to note that subjects *J* and *K*, who had been in the Keswick area of the Lake District until October 17, had appreciably lower iodine-131 uptakes than Leeds residents—an illustration of the effect of wind directions during and after release of activity from the pile. Subject *T*, who until the afternoon of November 2 had been resident in Cambridge, had a thyroid content of less than 10^{-9} c. iodine-131 when measured on November 3.

An attempt was made to estimate the fraction of iodine-131 taken up by the thyroid of subject *A* and its effective half-life, by relating the observed uptake to the estimated intake through milk. (Although milk was undoubtedly the main source of iodine-131, it is possible that it was not the only one.) Reasonable agreement (Table 3) was obtained for a thyroid uptake of 44 per cent and an effective half-life for iodine-131 in the thyroid of 7 days. Both figures are rather high for a normal subject, but the exact intake of milk was somewhat uncertain and, furthermore, the response was sensitive to the thyroid-detector geometry. However, a value of 8·5 nc. measured for this subject on November 1 at the Radiological Protection Service, Sutton[3], is slightly greater than the value of 7·5 interpolated from the smooth curve of Fig. 1 (although a straight line drawn through the points for October 31 and November 2 intersects the ordinate for November 1 at 8·5 nc.).

The dose to subject *A*'s thyroid tissue was calculated by performing a numerical integration for the period October 13–27 and assuming that the decay of activity from October 28 to infinity was exponential, with an effective half-life of 9·6 days. Assuming a thyroid mass of 30 gm. and that the γ-dose was 10 per cent of the β-dose, the total (β + γ) dose was $0{\cdot}09_5$ rad. A similar calculation for subject *B* gave a total (β + γ) dose to thyroid tissue of $0{\cdot}09_1$ rad.

Table 3. COMPARISON BETWEEN MEASURED UPTAKE OF IODINE-131 IN THE THYROID OF SUBJECT *A*, AND CALCULATED UPTAKE, ASSUMING AN AVERAGE INTAKE OF 1·2 PINTS MILK DAILY FROM A LEEDS MULTIPLE DAIRY (*MA*), AN IODINE-131 UPTAKE OF 44 PER CENT IN THE THYROID AND AN EFFECTIVE HALF-LIFE FOR IODINE-131 IN THE THYROID OF 7 DAYS

Date	Observed uptake (in units of 10^{-9} c. iodine-131)	Calculated uptake (in units of 10^{-9} c. iodine-131)	Date	Observed uptake (in units of 10^{-9} c. iodine-131)	Calculated uptake (in units of 10^{-9} c. iodine-131)
Oct. 15	4·1		Oct. 30	8·7	9·4
16	5·2	5·2 assumed	31	8·2	
			Nov. 1	8·8	
17	11	8·2	2		6·8 assumed
18	8·4	9·8			
19	8·6	10·9	3	5·8	6·3
20		13·4	4	5·8	5·8
21	14	12·9	5	5·5	5·4
22	11	12·5	6	5·3	5·0
23	11	11·9	7	4·4	4·6
24	10	11·6	8	3·9	4·2
25	11	11·1	9	3·9	4·0
26		11·0 assumed	10		
			11	3·0	
27		11·5	12	4·0	
28	9·8	10·8	13	3·1	
29	9·8	10·1	14	3·3	

These doses are about the same as the soft-tissue dose received in one year from natural sources of radiation[4] (predominantly local γ-rays, potassium in tissue and cosmic rays). Thyroid doses for adult Leeds residents drinking about one pint of milk daily from the Farsley farm would have been about 0·2 rad and adult Skipton residents would have received some 0·3–0·5 rad. Since the uptake of iodine-131 in the thyroid of subject *N* (4-year-old Leeds boy drinking milk from one of the Leeds multiple dairies) is about the same as for adults drinking similar quantities of the same milk, the dose to his thyroid tissue will be higher (by about four times), in inverse ratio to the thyroid masses.

I am a member of the External Scientific Staff of the Medical Research Council, and am indebted to Mr. D. B. Appleby for extensive assistance with these observations.

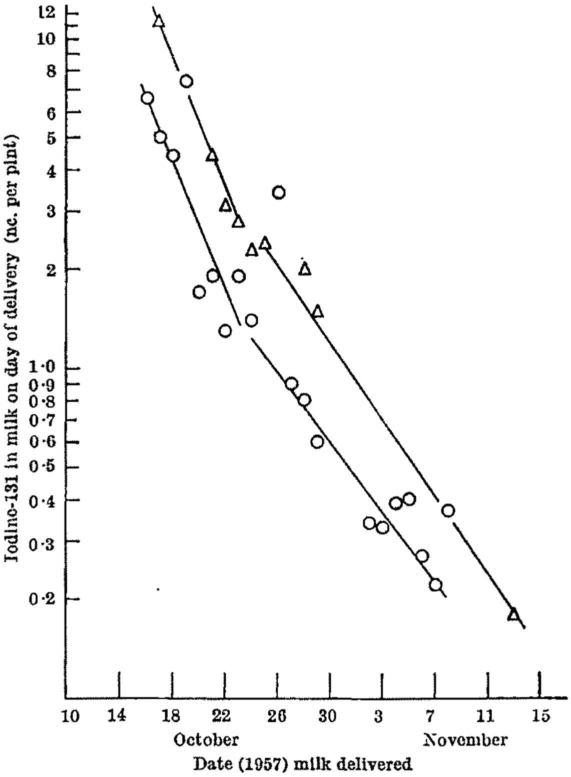

Fig. 2. Iodine-131 concentration (nc. per pint) in milk from a Leeds multiple dairy (*MA*) (○) and from a farm at Farsley (*ME*) (△) versus the date of delivery of the milk

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[3] Maycock, G., and Vennart, J., *Nature*, 182, 1545 (1958).

[4] Medical Research Council Report, Cmd. 9780, Appendix J, 107 (H.M.S.O., 1956).

Increase in Background Gamma-Radiation and its Correlation with Iodine-131 in milk

By PROF. F. W. SPIERS

MEASUREMENTS of the γ-ray dose-rate over a lawn and in a house in Leeds had been made during August and September 1957 and it was possible to repeat the measurements on October 19, 1957, and to continue them for some months thereafter. Small, but significant, increases in dose-rate above the summer values were observed in October and it is interesting to consider their relation to the iodine-131 activity in Leeds milk reported in the previous communication.

The measurements were made with a portable high-pressure ionization chamber having long-term stability of response. The chamber, which has a steel wall 0·12 in. thick, operates with a gas filling of 50 atm. of nitrogen, and the change of potential of the central electrode is measured by applying a balancing voltage to the grid of a miniature triode in a Townsend balancing circuit. A drift of 1 V. corresponds to a dose of 0·092 µrad of radium γ-radiation and to 0·108 µrad of γ-radiation from iodine-131. A background γ-ray dose-rate of the order of 10 µrad per hour can be measured with a standard error of ± 1·5 per cent in a single observation of 3–4 min. The standard error of the observations reported here (means of 5 or more readings) is about ± 0·5 per cent.

The stability of response of the instrument is indicated by calibrations carried out with a standard radium source at a dose-rate of approximately 12 µrad/hr., which is of the same order as that from local γ-radiation. The '4π' calibration thus obtained in a large hall, under conditions of minimum scatter, was 0·092 µrad/V. in July 1957, and 0·093 and 0·094 µrad/V., respectively, in April and May 1958. The instrument response to radiation (mainly cosmic) in the Leeds steel room (see previous communication) was 0·465, 0·496, 0·517 and 0·493 V./min. on dates in July, October 1957 and March, May 1958, respectively. The radiation-level in the steel room is unaffected by adventitious changes in the local γ-ray intensity outside it; but the cosmic-ray ionization under the 9-in. steel shielding shows a variation with barometric pressure of − 3 per cent per cm. mercury. Apart from this effect, the response of the instrument in the steel room reflects the stability of the grid current of the electrometer valve which, at 1·9 × 10^{-15} amp., is equivalent to 2 per cent of the current obtained for a typical background γ-ray level. Tests showed that leakage across insulators was insufficient to cause a significant error in the instrument response.

Measurements made at intervals from August 1957 onwards are shown in Fig. 3 for a point 1 ft. above a small lawn, surrounded on three sides by garden but relatively close to the building line, and also for a point in the centre of a ground floor room facing the garden. The results show that, on October 19, 1957, the instrument response over the lawn was 0·23 V./min. above the summer value of 1·75 V./min., corresponding to an increase in γ-ray dose-rate of 1·36 µrad/hr. or about 12 mrad/year. The increase in dose-rate indoors was rather less than half this amount. After falling from the high values of October 19, the γ-ray dose-rates over the lawn and in the house then showed a more or less continued rise which levelled off in the spring of 1958; the relation of these later observations to possible bomb fall-out is the subject of a separate investigation. There can be little doubt that the sharp rise and fall of dose-rate shown in October 1957 was caused by deposition from the Windscale cloud. It is known from Chamberlain[1] that the escape of radioactivity from the reactor was mainly iodine-131 with at first a considerable fraction of the 3·2 day isotope tellurium-132 and its decay product iodine-132; small percentages of other γ-ray emitters, cæsium-137, rubidium-103 and zirconium-95 – niobium-95, were also present. It can thus be estimated that, of the total increase in γ-ray dose-rate of 1·36 µrad/hr. on October 19, 0·6 µrad/hr. was attributable to the isotope iodine-131.

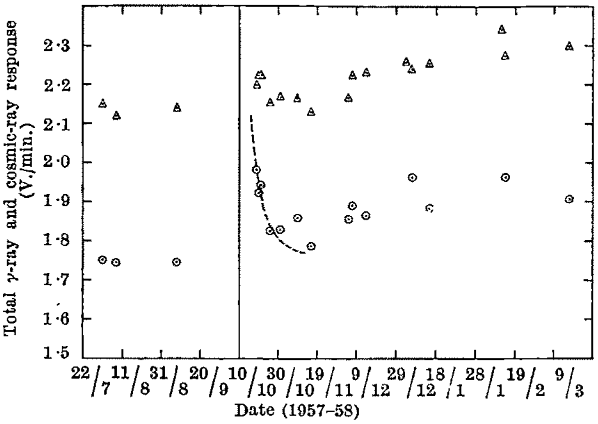

Fig. 3. Total response of a high-pressure ionization chamber to cosmic radiation, local γ-radiation and γ-radiation from adventitious radioactivity. △ over a lawn; ⊙ in a house. The dotted curve indicates the expected decay of the response for the iodine-131, tellurium-132, iodine-132 and other isotopes in the Windscale deposit

The relationship between the observed γ-ray dose-rates and the milk activity in Leeds can be compared with deductions from observations of the higher dose-rates and milk activities made in Cumberland by the Atomic Energy Authority. In order to compare directly with the Cumberland observations, however, some allowance must be made for the fact that the Leeds measurements were in a built-up area where the ionization chamber was screened from a considerable fraction of the radiation it would have received in open country. Chamberlain[1] has shown that the dose-rate at 1 m. above a circular area of radius 10 m. contaminated with iodine-131 is only 40 per cent of that from an infinite plane. It can be deduced that at the Leeds site, at about 3 m. from the building line, the observed dose-rate would be some 60 per cent of that for similarly contaminated open country. In addition to this shielding effect, the deposition of radioactivity would be affected to some extent by the 'shadowing' of near-by buildings. A very approximate factor of 2 has therefore been introduced at this stage, as an adjustment, before comparing the Leeds and Cumberland observations. In the following three comparisons the 'open country' dose-rates for the Leeds area on October 19 have been taken to be 2·7 µrad/hr. for the total increment in the γ-ray dose-rate and 1·2 µrad/hr. for the iodine-131 fraction.

(1) Calculations by Chamberlain[1] give the dose-rate over a uniformly contaminated plane as 7·7 µrad/hr. at 1 ft. for a contamination of 1µc. iodine-131 per $m.^2$. The iodine-131 dose-rate of 1·2 µrad/hr. corresponds, therefore, to a contamination of about 160 nc. iodine-131/$m.^2$ on October 19 and hence to 200 nc./$m.^2$ on October 16, on which date other measurements are available. The activity on the grass itself is about one-third of this (see below) and a figure of the implied magnitude, ~ 70 nc./$m.^2$, fits in with the nearest reported grass activities of 81 nc./$m.^2$ at Sheffield and 169 nc./$m.^2$ farther west at Burnley[2] on October 16.

(2) Chamberlain[1] reports a ratio of grass activity/ground activity of 0·16 on October 28 and it can be inferred from this and other results in his paper that the ratio was about 0·3 on October 19. Furthermore, a milk activity of 1 µc./l. was found to be associated with a grass activity of 11 µc./$m.^2$. It follows that a ground contamination of 160 nc/$m.^2$ in Leeds on October 19 should yield a milk activity of about 4·3 nc./l.

(3) A further empirical relationship evident in the Atomic Energy Authority results indicated that a milk activity of 1 µc./l. was associated with a γ-ray dose-rate of 0·45 mrad./hr. at 1 ft. above open ground.

The increment in the γ-ray dose-rate in Leeds of 2·7 μrad/hr. on October 19 would be associated, on this basis, with a milk activity of 6·0 nc./l. This expected value and that in (2) are in reasonable accord with the iodine-131 contents of Leeds milks which on October 20 ranged from 2·5 to 10·5 nc./l. with a mean of 7 nc./l.

It is evident from these comparisons that, with the introduction of a factor 2 for the shielding in the built-up area, the ratios of the γ-ray dose-rates to the milk activities, measured at trace-levels in Leeds, are in substantial agreement with those observed at levels some hundred times greater in Cumberland.

In addition to comparisons with similar observations by the Atomic Energy Authority, it is of interest to see to what extent the results of the milk and γ-ray measurements fit in with theoretical estimations based on the cow's known grazing habits and its metabolism of iodine. The basic data required[3] are the average area grazed by a cow per day and the iodine-131 level in cow's milk on the days following the ingestion of a known quantity of that isotope[4]. A relationship between the activity on the ground and the fraction retained by the grass must also be known; this can be based on measurements given by Chamberlain[1] for October 28. It is to be expected that this fraction must change with time and there is experimental evidence for this in Fig. 4 of Chamberlain's paper, where the ratio of ground iodine-131 activity to the milk activity increases with time. If, following Chamberlain's data, the ratio of grass to ground activity is assumed to be 0·45 on October 11, and falling to 0·3 on October 18, the ground contamination of 160 nc./m.[2] given above for October 19, together with the biological data, would lead to an expected milk activity of 48 nc./l.—a value some seven times higher than the mean observed in Leeds. Other calculations, on the basis of a grass/ground fraction of 0·16 on October 18 and a half-period of 3 days for iodine-131 on grass (as was observed for Leeds milk), lead to lower values for the milk activity, but such assumptions would seem to be less plausible.

Neither the Leeds observations, nor, by inference, those of the Atomic Energy Authority, would seem to fit the biological data at all well, but it is scarcely to be expected that any close correlation would be shown when milk is drawn from a wide area and the autumn feeding regime is likely to be very variable. Further experimental investigations of the relation between grass contamination and ground γ-ray dose-rate and its variation with time after deposition would, however, appear to be very worth while.

I am indebted to Mr. D. B. Appleby and to Mr. R. Corry for assistance in the design of the portable high-pressure ionization chamber and for its construction.

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VITAMIN B$_{12}$ AND PROTEIN BIOSYNTHESIS

Vitamin B$_{12}$ and Biosynthesis in Chick Liver

By Dr. M. J. FRASER and Dr. E. S. HOLDSWORTH

National Institute for Research in Dairying, Shinfield, Nr. Reading

In recent years evidence has been produced that the steps of incorporation of amino-acids into proteins include: (i) an activation dependent on adenosine triphosphate of the amino-acids through the COOH group, with the formation of an amino-acid–adenosine monophosphate complex by means of enzymes present in the soluble cell-sap; (ii) stabilization of the activated amino-acid by the transfer to a ribonucleic acid of low molecular weight present in the soluble cell-sap; (iii) a transfer dependent on guanosine triphosphate of the amino-acid to the microsomal ribonucleoprotein where peptide bond-formation apparently takes place.

A microsome-rich preparation which contains all the necessary components for these steps of incorporation was prepared by Wagle, Mehta and Johnson[1] from the livers and spleens of vitamin B$_{12}$-deficient and normal rats. They found that the deficient preparations incorporated less carbon-14 labelled methionine, alanine or phenylalanine into protein. Addition of vitamin B$_{12}$ *in vitro* significantly increased incorporation into both deficient and normal preparations. In a later paper[2], these workers suggested that vitamin B$_{12}$ is associated with the enzymes concerned with the activation of the amino-acids.

The purpose of this communication is to report on observations we made with preparations from normal and deficient chick livers, which have led us to different conclusions.

Experimental methods. All the chicks used in this work were hatched from eggs from hens given an all-vegetable diet deficient in vitamin B$_{12}$ and were maintained for 4 weeks as described by Coates, Harrison and Kon[3]. Typical weights at 4 weeks were: deficient birds, 120 gm.; control birds (receiving vitamin B$_{12}$ 1 μgm./100 gm. diet), 200 gm.

The carbon-14 labelled amino-acids and phosphate (^{32}P) were obtained from the Radiochemical Centre, Amersham. Vitamin B$_{12}$ labelled with cobalt-60 was kindly provided by Dr. E. L. Smith, of Glaxo Laboratories, Ltd.

We are grateful to our colleague, Dr. M. E. Gregory, for the microbiological assays of vitamin B$_{12}$, which were made with *Lactobacillus leichmannii* (Gregory)[4].

Determinations of cobalt-60 were made in a well-type, activated sodium iodide crystal scintillation counter. Standards were counted at the same time and all results are expressed as micrograms of vitamin B$_{12}$. All carbon-14 and phosphorus-32 samples were counted in a 'Tracerlab' gas-flow counter. The counts recorded here are presented as counts/min./cm.^{2} at infinite thickness, corrected for background.

The chicks were killed by breaking the neck. Livers were quickly excised and plunged into ice-cold 0·25 *M* sucrose, or medium *A*[5]. After cooling for a few minutes, they were dried rapidly on filter paper and minced with an ice-cold metal mincer. The mince was then suspended in 2·3 volumes of medium *A*, or 3·0 volumes of 0·25 *M* sucrose, buffered or unbuffered according to the particular needs of the experiment. The suspensions were homogenized in a Potter–Elvehjem homogenizer having a loose-fitting

Table 1. Distribution of Cobalt-60-B_{12} in Chick Livers

Cell fraction	mμgm. Cobalt-60 vitamin B_{12}	Percentage of total
Debris	11·6	58·8
Mitochondria	0·75	3·8
Microsomes	0·93	4·7
Supernatant	6·5	32·8
(i) *p*H 5 enzyme	1·2	5·9
(ii) *p*H 5 supernatant	5·3	26·9

nylon pestle, six passes at approximately 1,000 rev./min. being made within 20 sec. The cell fractions were then separated by differential centrifugation for 10 min. at 700*g*, to sediment debris and nuclei, for 10 min. at 7,000*g* for mitochondria and for 1 hr. at 105,000*g* to sediment microsomes. The *p*H 5 enzymes were prepared essentially as described by Hoagland, Keller and Zamecnik[6], washed once with approximately 10 volumes of ice-cold 0·15 potassium chloride and the precipitated *p*H 5 enzymes redissolved in a volume of the appropriate medium equivalent to the weight of tissue used in the preparation. Under these conditions the concentrations of protein (10–15 mgm./ml.) and of soluble cell-sap nucleic acid (2·5–3 per cent of the protein) from both B_{12}-deficient and normal chick livers were the same. The concentration of soluble cell-sap nucleic acid was determined by the method of Hoagland, Stephenson, Scott, Hecht and Zamecnik[7].

The protein samples for counting were isolated by precipitation with 10 per cent trichloracetic acid containing 1 per cent of appropriate carrier. The precipitates were afterwards put through the twelve-stage procedure described by Simkin and Work[8]. The total *p*H 5 fraction, consisting of *p*H 5 protein with soluble cell-sap nucleic acid, was precipitated in ice-cold 5 per cent trichloracetic acid containing 1 per cent carrier, washed twice with ice-cold 5 per cent trichloracetic acid, then with 95 per cent ethanol, acetone, ethanol/ether (3 : 1) and finally ether.

Vitamin B_{12} in Chick Livers and its Distribution in the Cells

The vitamin B_{12} content of the deficient chick livers used in these experiments ranged from 0·012 to 0·017 μgm./gm. fresh liver, whereas those of control birds contained 0·077–0·090 μgm./gm. Only a small proportion (approximately 10 per cent) of the vitamin was found in the *p*H 5 enzymes isolated from these livers; for example, the *p*H 5 enzymes from 1 gm. fresh deficient liver contained 0·8 mμgm. vitamin B_{12} and those from 1 gm. normal liver, 7·0 mμgm. vitamin B_{12}. To study the distribution of vitamin B_{12}, three deficient chicks, average weight 120 gm., were given two intramuscular injections of 1 μgm. cobalt-60 vitamin B_{12} (= 0·24 μc.), one 48 hr. and the other 24 hr. before removal of the livers. The livers were pooled, minced and cell fractions prepared. The distribution of cobalt-60 radioactivity, which is assumed to be vitamin B_{12}, is shown in Table 1. The deficient livers, which would probably contain approximately 15 mμgm./gm. of 'natural' vitamin B_{12}, took up another 20 mμgm./gm. of the vitamin; but, contrary to the findings of Wagle *et al.*[2], the *p*H 5 enzymes contained only a small proportion, 5·9 per cent, of this additional vitamin B_{12}. The largest amount of the vitamin was found in the cell supernatant fraction. Very similar results were obtained by incubation of 3 gm. deficient liver mince from similar birds with 2 μgm. cobalt-60 vitamin B_{12} *in vitro*. Therefore, there seems no reason for describing the *p*H 5 enzymes as the "vitamin B_{12} enzyme"[2].

In vitro Incorporation of Amino-acids in Chick Liver

(i) *Mince experiments.* Immediately after mincing, 3-gm. portions of deficient or normal livers and 9 ml. ice-cold Krebs–Ringer bicarbonate–glucose buffer[9] were put into Krebs pots. The buffer contained 0·25 *M* sucrose and 2 μc. carbon-14 *Chlorella* hydrolysate (specific activity 60 μc./mgm.). The samples were incubated at 38° C. in a Warburg bath with gentle shaking and continuous gassing with oxygen + 5 per cent carbon dioxide. After appropriate intervals the flasks were removed and kept in an ice-bath. The mince suspensions were homogenized in their medium, cell fractions separated and counted.

In all, four mince experiments were carried out. In two there was a slight effect of addition of vitamin B_{12} to deficient livers and in the other two no effect. The results are shown in Table 2. In Table 2*A* it is shown that the deficient livers incorporated less carbon-14 amino-acids into cell debris, mitochondria and supernatant proteins, although there was no difference in incorporation into microsomes, which is taken to be the first site of peptide bond formation. In these two experiments with deficient livers when vitamin B_{12} had an effect, the incorporation increased up to the level of that in control livers without affecting incorporation into microsomes. The other type of situation encountered is shown in Table 2*B*. Here the deficient livers incorporated less amino-acids into cell fractions, including microsomes, but addition of vitamin B_{12} had no effect on the incorporation.

Table 2. Incorporation of Amino-acids into Chick Liver Mince
2 μc. Carbon-14-*Chlorella* amino-acids per 3 gm. mince and 9 ml. Krebs–Ringer–sucrose. Incubation in oxygen plus 5 per cent carbon dioxide at 38° C.

Proteins of cell fraction	Time (min.)	Counts/min./cm.²		
		Normal	Deficient	Deficient + 2 μgm. vitamin B_{12}
		(*A*)		
Debris	0	8	4	4
	20	67	53	61
	40	91	55	88
Mitochondria	0	0	0	9
	20	82	49	57
	40	103	66	91
Microsomes	0	0	0	0
	20	92	96	130
	40	132	139	137
Supernatant	0	8	7	7
	20	35	36	38
	40	50	44	63
		(*B*)		
Debris + mitochondria	0	11	13	10
	5	22	18	14
	20	45	37	38
	40	108	35	35
	120	158	76	67
Microsomes	0	6	8	4
	5	24	22	18
	20	77	86	86
	40	146	82	78
	120	147	95	81
Supernatant	0	29	41	30
	5	35	35	46
	20	45	55	52
	40	88	47	49
	120	126	49	55

In view of the variable results obtained with the minces, we examined microsome-rich and pH 5 enzyme systems.

(ii) *Microsome-rich fractions.* The microsome plus supernatant fraction, prepared from a homogenate of liver mince with 3 vol. of 0·25 *M* sucrose, was incubated together with the carbon-14 amino-acid (final concentration usually 0·5 μc./ml.), magnesium ions, adenosine triphosphate buffer at pH 7·4, and with potassium 3-phosphoglycerate as described by Simkin and Work[10]. Incubation was at 38° with vigorous gassing with either nitrogen + 5 per cent carbon dioxide (anaerobic) or oxygen + 5 per cent carbon dioxide (aerobic), and samples were taken at 0, 20 and 40 min. for precipitation with 10 per cent trichloracetic acid containing 1 per cent carrier to give microsome-rich protein fraction or for dilution with ice-cold 0·25 *M* sucrose, containing 0·005 *M* carrier amino-acid, from which the microsomes were separated by centrifugation.

With carboxyl-labelled DL-alanine the effect of graded amounts of cyano- or hydroxo-cobalamin on incorporation into microsome-rich protein was studied and the results are shown in Table 3. With this amino-acid, in two experiments, we obtained greater incorporation into the deficient preparations, and *in vitro* addition of *both* forms of the vitamin slightly increased incorporation into deficient preparations.

The generally labelled amino-acids of *Chlorella* hydrolysate were incorporated to the same extent into the microsome-rich protein of deficient and normal chick livers (Table 4). Vitamin B_{12} added *in vitro* to deficient preparations was without effect (two experiments) and there was no difference in incorporation in aerobiosis or anaerobiosis. Table 5 shows the incorporation of carbon-14 L-leucine into microsomal proteins, and in this instance there was less incorporation into deficient preparations; but again vitamin B_{12} had no effect on the amount of incorporation. The anilide of the monocarboxylic acid prepared from vitamin B_{12}[11,12], which has a growth inhibition index for *E. coli* 113/3 of 2,000, had a very slight depressing effect on incorporation when used at a high concentration of 280 μgm./ml. Dr. M. E. Coates (personal communication) has found that this substance antagonizes the growth of chicks. Chloramphenicol at a bactericidal concentration (200 μgm./ml.) did not inhibit incorporation. This phenomenon has been noted by other workers in mammalian systems (for example, rat liver and guinea pig mammary gland, Fraser, M. J., Shimizu, H., and Gutfreund, H. G., unpublished work) and suggests that the reported incorporations are not due to bacterial contamination. In further experiments with leucine, vitamin B_{12} and the anilide did not alter the amount of amino-acid taken up; but in these experiments there was no difference between normal and deficient preparations.

Table 3. INCORPORATION OF ALANINE INTO MICROSOME-RICH FRACTION OF CHICK LIVER. EFFECT OF GRADED DOSES OF VITAMIN B_{12}

0·5 μc. Carbon-14 DL-alanine per ml. final medium (see text); time of incubation 20 min. Incubation in nitrogen plus 5 per cent carbon dioxide at 38° C.

	Counts/min./cm.^{2} total microsome-rich protein	
	Normal chicks	Deficient chicks
Cyanocobalamin (mμgm./ml.)		
Blank (zero time)	0	7
0	50	57
25	40	67
100	40	73
500	43	70
Hydroxocobalamin (mμgm./ml.)		
Blank (zero time)	0	2
0	50	57
50	47	70
250	47	76

Table 4. INCORPORATION OF AMINO-ACIDS INTO MICROSOME-RICH FRACTION OF CHICK LIVER

0·93 μc. Carbon-14-*Chlorella* amino-acids per ml. final medium (see text). Incubation in either oxygen plus 5 per cent carbon dioxide (aerobic) or nitrogen plus 5 per cent carbon dioxide (anaerobic) at 38°C.

Time (min.)	Counts/min./cm.^{2} total microsome-rich protein					
	Aerobic			Anaerobic		
	Normal	Deficient	Deficient + 2 μgm. vitamin B_{12}/3 ml.	Normal	Deficient	Deficient + 2 μgm. vitamin B_{12}/3 ml.
0	50	62	60	50	55	55
20	174	162	169	153	156	159
40	206	211	221	204	230	210

Table 5. INCORPORATION OF LEUCINE INTO MICROSOME-RICH FRACTION OF CHICK LIVER. EFFECT OF VITAMIN B_{12} AND ANTI-VITAMIN B_{12} AND CHLORAMPHENICOL

0·55 μc. Carbon-14 generally labelled L-leucine per ml., final medium (see text). Incubation in nitrogen plus 5 per cent carbon dioxide at 38° C. Vitamin B_{12} and its peptide complex added at 280 mμgm./ml. and the anilide of vitamin B_{12} 280,000 mμgm./ml. Chloramphenicol was added at 200 μgm./ml. medium

Time (min.)	Counts/min./cm.^{2} microsomal protein						
	Normal	Normal + vitamin B_{12}	Normal + anti-vitamin B_{12}	Normal + chloramphenicol	Deficient	Deficient + vitamin B_{12}	Deficient + vitamin B_{12} peptide
0	30	27	33	47	50	43	43
20	177	170	140	190	100	104	93
40	220	224	183	233	110	110	100

Amino-acid Activation

(i) *Hydroxamate test.* The particle-free supernatant fraction was used to follow the rate of formation of amino-acid hydroxamate essentially as described by Hoagland, Keller and Zamecnik[6]. The incubation mixture contained 5 ml. 2 *M* salt-free hydroxylamine, 1 ml. 0·01 *M* magnesium potassium adenosine triphosphate (MgK_2ATP), 2 ml. complete amino-acid mixture giving in the medium a 0·02-*M* concentration of each amino-acid, 1 ml. 1 *M tris* buffer pH 7·6 and 1 ml. cell-supernatant proteins. The blank control contained everything except the amino-acid mixture, and the substantial colour obtained in it was due to formation of hydroxamate by endogenous amino-acids and other compounds in the supernatant fraction.

Three experiments on the formation of hydroxamate were carried out and the results of one are shown in Fig. 1. In all experiments the deficient supernatant fraction had a rate of formation of hydroxamate, that is, of amino-acid activation, nearly twice that of the normal preparation, and it was not changed by *in vitro* addition of vitamin B_{12}.

(ii) *Pyrophosphate exchange.* A dilution of the pH 5 enzyme 1 : 10 with *tris* buffer pH 7·6 was used to measure the adenosine triphosphate–phosphate (^{32}P) exchange. The final incubation mixture contained 0·002 *M* adenosine triphosphate, 0·002 *M* phosphate (^{32}P), 0·01 *M* magnesium chloride, 0·5 mgm./ml. of pH 5 enzyme, 0·1 *M tris* buffer pH 7·6 and a single amino-acid, 0·001 *M*, either alanine, leucine or tryptophan. After incubation at 37° C. for various lengths of time, 3-ml. samples were taken into

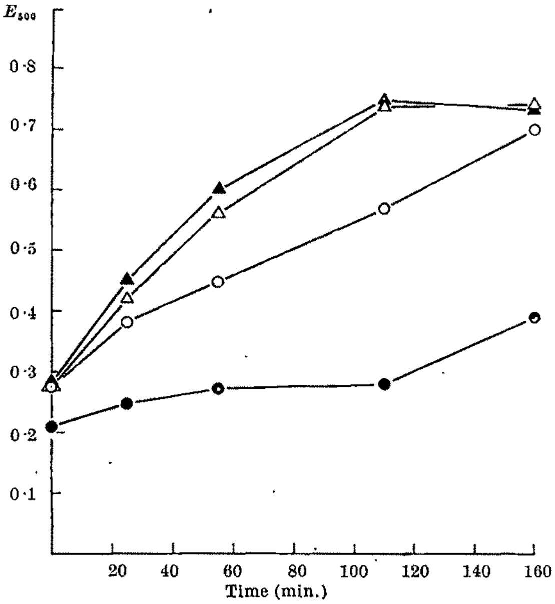

Fig. 1. Formation of hydroxamate in chick liver supernatant fractions

Hydroxamate formed after incubation of cell supernatant with a complete mixture of amino-acids. △, Deficient-liver supernatant; ▲, deficient-liver supernatant + 200 μgm. B_{12}/ml.; ○, normal liver supernatant; ●, blank, that is, without amino-acid mixture

7 ml. 10 per cent trichloracetic acid. The precipitated protein was removed and the adenosine triphosphate (^{32}P) was adsorbed on 100 mgm. activated charcoal as described by Crane and Lipmann[13] and counted.

In duplicate experiments using alanine and leucine, there was no significant difference between deficient and normal *p*H 5 enzymes, in the amount of phosphate (^{32}P) exchange. Vitamin B_{12} added to the deficient enzyme had no effect on the system, as can be seen in Table 6. However, addition of 2 mgm. of the anilide of vitamin B_{12} to the normal enzyme did depress the amount of exchange, in confirmation of the report of Wagle *et al.*[2]. Vitamin B_{12} even at high concentration only partially reversed this inhibition. Omission of the amino-acid from the incubation mixture had little effect on the exchange. Since the amount of endogenous amino-acid left on the washed and diluted *p*H 5 enzyme was probably very small, the pyrophosphate exchange may not have been measuring amino-acid activation. That the reaction was enzymic is shown by its inhibition by 10^{-4} *M* *p*-chloromercuribenzoate.

Table 6. PYROPHOSPHATE EXCHANGE INTO ADENOSINE TRIPHOSPHATE USING *p*H 5 ENZYMES FROM NORMAL AND DEFICIENT CHICK LIVER
Final medium contained: L-leucine, 0·001 *M*; MgK_2ATP, 0·002 *M*; $P^{32}P$, 0·002 *M*; Mg^{2+}, 0·01 *M*; *tris* buffer, 0·1 *M* *p*H 7·6 and *p*H 5 enzyme

*p*H 5 enzymes gave final protein concentration 0·35 mgm./ml. normal and 0·39 mgm./ml. deficient. The concentration of soluble cell-sap nucleic acid was 0·010 mgm./ml. for normal and 0·011 mgm./ml. for deficient

Vitamin B_{12} added at 200 mμgm./ml. and the anilide of vitamin B_{12} at 200,000 mμgm./ml.

Blank obtained by adding 10^{-4} *M* *p*-chlormercuribenzoate

Time (min.)	Adenosine triphosphate-^{32}P adsorbed on charcoal (counts/min./mgm. charcoal)				
	Blank 10^{-4} *M* *p*-chlormercuribenzoate	Normal	Normal + anti-vitamin B_{12}	Deficient	Deficient + vitamin B_{12}
0	0·22	0·33	0·44	0·43	0·25
15	0·56	10·2	6·68	11·2	10·5
30	0·50	20·1	12·7	22·5	22·6

(iii) *Incorporation of carbon-14 amino-acids into p*H *5 enzymes.* The *p*H 5 enzymes were dissolved in a buffered medium similar to that described by Keller and Zamecnik[5] containing 0·35 *M* sucrose, 0·035 *M* potassium bicarbonate, 0·025 *M* potassium chloride, 0·01 *M* magnesium potassium adenosine triphosphate, and 0·5 μc./ml. carbon-14 amino-acid. Incubation was at 37° C. for various times. The total labelled *p*H 5 fraction (that is, soluble cell-sap nucleic acid + protein) and also the labelled *p*H 5 protein were isolated. Three experiments with carbon-14 generally labelled L-leucine and one experiment with carbon-14 *Chlorella* hydrolysate gave very similar results. Fig. 2 shows results with leucine. In all experiments the deficient *p*H 5 enzyme, in spite of its lower vitamin B_{12} content, became labelled faster than the normal *p*H enzymes, the rate in some experiments being at least double. The effect was tried of a number of substances on the rate of incorporation. Neither the anilide derivative of vitamin B_{12} nor

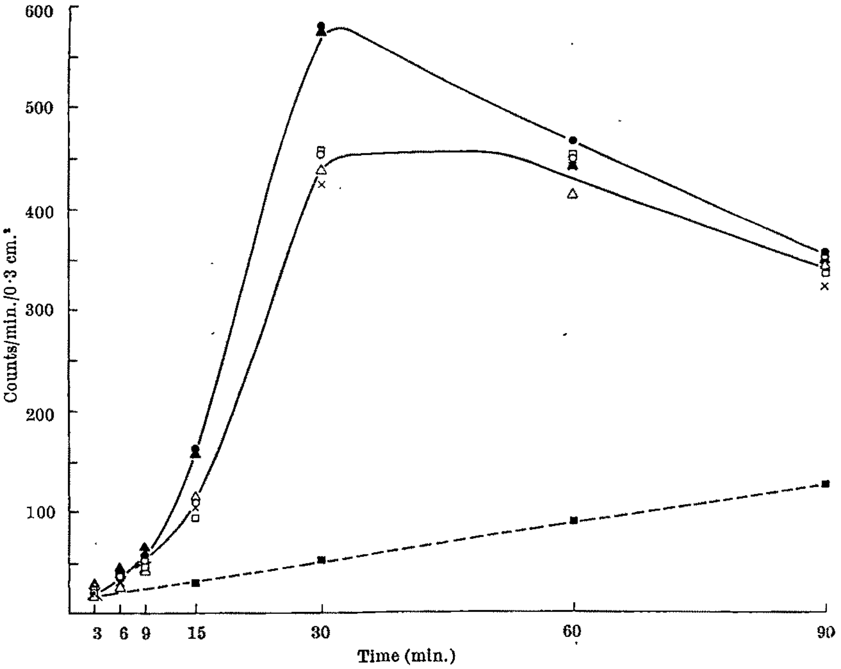

Fig. 2. Incorporation of carbon-14 L-leucine into *p*H 5 enzyme of chick liver *p*H 5 enzyme in medium *A* (ref. 5) with 0·5 μc. carbon-14 leucine/ml. Final concentration of soluble cell-sap nucleic acid of both enzymes was 0·25 mgm./ml. ○, Normal *p*H 5 enzyme; □, normal *p*H enzyme + 250 mμgm./ml. vitamin B_{12}; △, normal *p*H 5 enzyme + 50 μgm./ml. methylamide of vitamin B_{12}; × normal *p*H 5 enzyme + 50 μgm./ml. coenzyme A; ●, deficient *p*H enzyme; ▲, deficient *p*H 5 enzyme + 250 mμgm./ml. vitamin B_{12}; ■, protein fraction of *p*H 5 enzymes. All the points of the above six treatments coincide for the proteins alone

the corresponding methyl amide had any effect on the normal enzymes, and vitamin B_{12} itself did not affect deficient or normal preparations. Vitamin B_{12} deficiency often leads to an elevated level of coenzyme A in liver[14], which it was thought could account for the increased incorporation in deficient liver, since Airth, Rhodes and McElroy[15] have shown that coenzyme A can activate certain amino-acids via the carboxyl group in a manner analogous to acetate activation. However, it can be seen that coenzyme A did not increase the rate of incorporation of the normal *p*H 5 enzyme fraction. The proteins present in the *p*H 5 enzyme became labelled linearly to a final 26 per cent of the total carbon-14 in the soluble cell-sap nucleic acid plus protein fraction. Fig. 2 shows that both enzymes and the various treatments lead to the same amount of labelling in these proteins.

Discussion

For our study of the distribution of vitamin B_{12} in liver, we preferred to use deficient chicks, that is, chicks with depleted vitamin B_{12} stores, and inject a dose of cobalt-60 vitamin B_{12} smaller than that used by Wagle *et al.* for normal rats. A further difference was that our dose was given in two portions 48 hr. and 24 hr. before the liver was excised, allowing a greater chance for equilibrium to be established. In this way we found that most of the vitamin was in the *p*H 5 cell supernatant, and hence there was no reason for associating vitamin B_{12} with either the particulate fractions or more especially with the *p*H 5 precipitate that contains the amino-acid activating enzymes. This observation was further confirmed by the finding by direct microbiological assay that only 10 per cent of the total natural vitamin B_{12} content of both deficient and normal livers was present in the *p*H 5 fraction. Even though the *p*H 5 fraction from deficient liver contained only one-tenth of the vitamin B_{12} present in the normal *p*H 5 fraction, the rate of amino-acid activation measured by the hydroxamate test or by incorporation of labelled amino-acid into soluble cell-sap nucleic acid was twice as great as for the normal preparations. The total protein and nucleic acid concentration of the 'deficient' and 'normal' *p*H 5 enzymes were the same. Although the rate of activation appeared greater in deficient livers, the incorporation into microsomal protein was generally the same or lower than into the normal liver fractions. With the adenosine triphosphate – phosphate (^{32}P) exchange as a measure of amino-acid activation, the results are more difficult to interpret, since we did not demonstrate a requirement for amino-acid in our system. Whatever process this exchange is measuring, there was no difference between the normal and deficient *p*H 5 enzymes, and vitamin B_{12} did not affect the exchange. However, the exchange was 35 per cent inhibited by a high concentration of the anilide of vitamin B_{12}, in confirmation of the observation of Wagle *et al.*[2].

Using the more complex fractions rich in microsomes to measure all the steps concerned in the incorporation of amino-acids into protein, we observed in two out of six experiments that the deficient preparations incorporated less carbon-14 amino-acids than the normal. In only one experiment of the six with fractions rich in microsomes was there any indication of an effect of added vitamin B_{12}. Vitamin B_{12} was tested as its cyano-, hydroxo-, and peptide form, and was usually without effect on the incorporation of carbon-14 activity into protein. These results agree with those of Arnstein and Simkin (see following communication), who used vitamin B_{12}-deficient and normal rat-liver preparations rich in microsomes. The anilide of vitamin B_{12} was used at high concentration in two experiments, but there was no depression of incorporation.

Experiments with chick liver minces showed that incorporation of carbon-14 labelled amino-acids into these whole-cell preparations was always less in the minces of vitamin B_{12}-deficient liver. It appeared that a small and erratic effect was obtained in some experiments on the *in vitro* addition of vitamin B_{12}. In similar experiments in which carbon-14 amino-acids were given intravenously into live vitamin B_{12}-deficient chicks and also into deficient chicks that had been given large doses of vitamin B_{12} on two successive days before the experiment, we could find no difference in incorporation into liver or heart muscle proteins. These *in vitro* experiments varied in time from 30 min. to 5 hr. (Coates, M. E., and Holdsworth, E. S., unpublished work).

Since we have not been able to find a direct role of vitamin B_{12} in the activation of amino-acid or in the incorporation into fractions rich in microsomes, it seems probable that the differences in levels of incorporation occasionally observed between deficient and normal microsome-rich preparations, and usually observed in the mince preparations, may reflect an indirect role of vitamin B_{12}.

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Vitamin B_{12} and Biosynthesis in Rat Liver

By Dr. H. R. V. ARNSTEIN and Dr. J. L. SIMKIN*

National Institute for Medical Research, Mill Hill, N.W.7

THE nutritional importance of vitamin B_{12} for a wide variety of organisms, including mammals, birds, and micro-organisms, is well established. The underlying biochemical functions of the vitamin are, however, still unknown, although several different mechanisms have been suggested (for a recent review see ref. 1). An attractive suggestion, which could explain the diversity of the observed metabolic disturbances in deficient organisms, is the direct participation of vitamin B_{12} in protein biosynthesis and hence in enzyme formation[2,3]. The experimental basis for such a function is the decreased incorporation of labelled serine and glucose into the liver protein of vitamin B_{12}-deficient pigs and rats compared with that found in control animals *in vivo*[2],

* Present address: Department of Biological Chemistry, University of Aberdeen.

Table 1. VITAMIN B_{12} CONTENT OF LIVERS AND GROWTH OF DEFICIENT AND CONTROL RATS

Exp. No.	Litter and rat No.	Sex	Age (days)	Age when started on oral cyanocobalamin* (days)	Body-weight (gm.)	Vitamin B_{12} content of liver (mμgm./gm. fresh wt.)
1	*AL*72/2	*F*	91	—	143	32
2	*AL*72/1	*F*	75	30	136	200
3	*AL*76/3	*F*	80	—	148	40
4	*AL*76/5	*F*	80	67	160	100
5	*AL*78/2	*M*	63	—	98	16
	*AL*78/3	*M*	63	—	86	20
	*AL*78/4	*F*	63	—	92	44
	*AL*79/4	*F*	63	—	106	30
	*AL*79/2	*M*	63	32	174	120
	*AL*79/1	*F*	63	32	152	195
6	*AL*78/5	*M*	71	—	122	25
	*AL*79/3	*M*	71	—	107	13
	*AL*80/4	*F*	71	—	70	7
	*AL*78/1	*M*	71	32	170	160
	*AL*80/1	*M*	71	31	151	172
	*AL*80/2	*F*	71	31	120	185

*A dash signifies no cyanocobalamin given

and the reduced labelling of microsome protein of both liver and spleen in a cell-free system[3]. Moreover, the addition of vitamin B_{12} *in vitro* to such a cell-free system from deficient rats has been reported to stimulate the incorporation of labelled methionine, alanine or phenylalanine into protein and thus to be effective in partially restoring protein synthesis to normal levels[3]. This effect of vitamin B_{12} has been ascribed to a function in the carboxyl-activation of amino-acids[4].

Other experimental evidence, however, appears to be in conflict with the foregoing results on the effect of vitamin B_{12} on protein synthesis in the intact rat. Thus, in the rat the incorporation of carbon-14-labelled methionine[5], serine[6], glycine[6] and histidine[7] into protein *in vivo* was not markedly decreased by vitamin B_{12} deficiency. In view of this discrepancy, the present experiments were undertaken in order to investigate further the suggested relationship of vitamin B_{12} to protein synthesis.

Vitamin B_{12}-deficient albino rats were obtained by breeding from depleted mothers which had also been fed on the vitamin B_{12}-deficient diet during pregnancy. The diet[8] had the following composition (gm./100 gm.): soya protein (α-protein, Glidden Co., Chicago, Illinois), 35; lactose, 17; glucose, 30; semi-hardened arachis oil (m.p. 33–35°; British Oil and Cake Mills, Erith), 12; salts (Glaxo mixture No. *DL*6), 5; vitaminized arachis oil[9], 2; and choline chloride, 0·3. Control animals were given vitamin B_{12} (cyanocobalamin) orally soon after weaning in doses equivalent to 5 μgm./rat/day (Table 1). With this diet, differences in body-weight between deficient and control rats usually became quite marked after 4–6 weeks. All livers used in the present experiments were checked for vitamin B_{12} depletion by microbiological assay with *Ochromonas malhamensis* essentially as described by Ford[10]. The average vitamin B_{12} content of deficient livers was 25 mμgm./gm. fresh weight, while livers of control rats contained about 160 mμgm./gm. (Table 1).

Minces were prepared by forcing liver through a metal screen with holes of 1 mm. diameter. Samples (0·5 gm.) from non-fasted deficient and control rats were incubated for 1·5 and 3 hr. under 95 per cent oxygen – 5 per cent carbon dioxide in 10 ml. of bicarbonate medium[11] with or without glucose (10·8 mgm.) and either uniformly labelled L-[^{14}C]valine (0·2 or 0·4 μc.; specific radioactivity, 53 μc./mgm.) or L-[^{14}C]phenylalanine (1 μc.; specific radioactivity, 70 μc./mgm.). After incubation, the flasks were cooled in ice, the medium was decanted and filtered through cotton wool, and the mince was washed twice with 2·5 ml. of 0·56 per cent sodium chloride. An equal volume of 10 per cent trichloracetic acid was added to the combined medium and washings to precipitate the protein (medium protein). The washed mince was suspended in 10 ml. of 0·56 per cent sodium chloride and disintegrated in a Potter–Elvehjem homogenizer with a 'Teflon' pestle. The suspension was centrifuged at approximately 700g for 10 min., the sediment was washed with 5 ml. of 0·56 per cent sodium chloride and centrifuged again. The 'soluble cell protein fraction' was precipitated from the original supernatant and washings by adding 10 per cent trichloracetic acid (15 ml.). The 'insoluble cell protein fraction' was obtained by adding 15 ml. of 10 per cent trichloracetic acid to the washed sediment. Each protein fraction was purified by dissolving in *N* sodium hydroxide, adding 10 mgm. of the appropriate unlabelled amino-acid, reprecipitating with 10 per cent trichloracetic acid and removing nucleic acid and lipid as previously described[12].

Table 2 shows that all protein fractions from minces of deficient rats had a lower specific radioactivity than those of controls, the greatest difference being found in the protein of the incubation medium. Addition of vitamin B_{12} *in vitro* increased the radioactivity of the protein only very slightly, however, the increase being usually less than 10 per cent. Since the uptake of vitamin B_{12} by rat liver slices is known to be rapid[13], absence of any marked stimulation of protein synthesis after incubation for 3 hr. would appear to exclude any direct effect of vitamin B_{12} on protein synthesis by intact liver cells.

Cell-free preparations were obtained by homogenizing rat liver in 0·25 *M* sucrose and separating the

Table 2. PROTEIN BIOSYNTHESIS BY LIVER MINCE FROM VITAMIN B_{12}-DEFICIENT AND CONTROL RATS

All results are calculated on the basis of 1 μc. of carbon-14 amino-acid added per flask. Except for experiment No. 2, results are means of duplicate flasks; individual values differed from the mean by less than 10 per cent in nearly all cases. In experiments Nos. 1 and 2, glucose (10·8 mgm./flask) was added to the medium

Exp. No.	Animal	Radioactive amino-acid added	Cyanocobalamin (10 μgm./flask)	Specific radioactivity of protein (mμc./gm.) after incubation for 1·5 hr. and 3 hr.					
				Protein from medium		'Soluble' cell protein		'Insoluble' cell protein	
				1·5 hr.	3 hr.	1·5 hr.	3 hr.	1·5 hr.	3 hr.
1	Deficient	Valine	–	54	200	435	860	198	352
			+	66	221	414	907	131	337
2	Control	Valine	–	—	665	—	1,139	—	650
			+	—	631	—	1,170	—	650
3	Deficient	Phenylalanine	–	97	350	1,289	2,021	465	854
			+	99	429	1,316	2,275	485	939
4	Control	Phenylalanine	–	159	604	1,685	2,585	664	1,075

microsome – cell sap fraction[14]. Samples of that fraction (2·5 ml.) were incubated at 37° under 95 per cent nitrogen – 5 per cent carbon dioxide with 3-phosphoglycerate as adenosine triphosphate generator and other additions as described elsewhere[15], the total volume being scaled down to 3·6 ml. Each flask contained 2 μc. of L-[^{14}C]phenylalanine (specific radioactivity 70 μc./mgm.). At the end of the incubation period, 2·5 vol. of cold 0·25 *M* sucrose containing unlabelled phenylalanine (1 mgm./ml.) were added and the mixture was centrifuged[15]. Protein was isolated from the microsome and supernatant (cell-sap) fractions[15] and purified as described above.

Fig. 1 shows that the cell-free system from vitamin B_{12}-deficient rats which had been fasted overnight incorporated somewhat less radioactivity into the protein of the microsome and cell-sap fractions than a similar preparation from the control animals. *In vitro* addition of cyanocobalamin (final concentration, 28 mμgm./ml.) had, however, no effect either on the rate of incorporation of phenylalanine into protein or on the final level of labelling. In another experiment with non-fasted rats (Table 3) a higher level of cyanocobalamin (140 mμgm./ml.) was equally ineffective in stimulating incorporation of phenylalanine, either alone or when added together with glutathione ($2·5 \times 10^{-3}$ *M*). Glutathione itself stimulated incorporation (cf. ref. 16), but the effect was relatively small. In a similar experiment with fasted rats which had been fed on a soya flour diet[10] instead of on the α-protein diet, the incorporation of a mixture of labelled amino-acids from hydrolysed [^{14}C]*Chlorella* protein into microsome protein was studied. The growth of deficient rats was retarded, but their livers were not as markedly depleted as those in the experiments in Table 1. Deficient animals had body-weights of 87, 95 and 105 gm. and a mean level of vitamin B_{12} in the liver of 98 mμgm./gm.; the corresponding values for control rats were 122, 122, 119 gm., and 160 mμgm./gm. Incubation was carried out under either 95 per cent nitrogen – 5 per cent carbon dioxide (for 10 min.) or 95 per cent oxygen – 5 per cent carbon dioxide (for 10 and 20 min.) and cyanocobalamin was added at 100 mμgm./ml. There was no significant difference in the radioactivity of the microsome protein of the preparations from the deficient and control animals. The radioactivity of the protein of the deficient cell-free system was increased by the addition of vitamin B_{12} by less than 15 per cent.

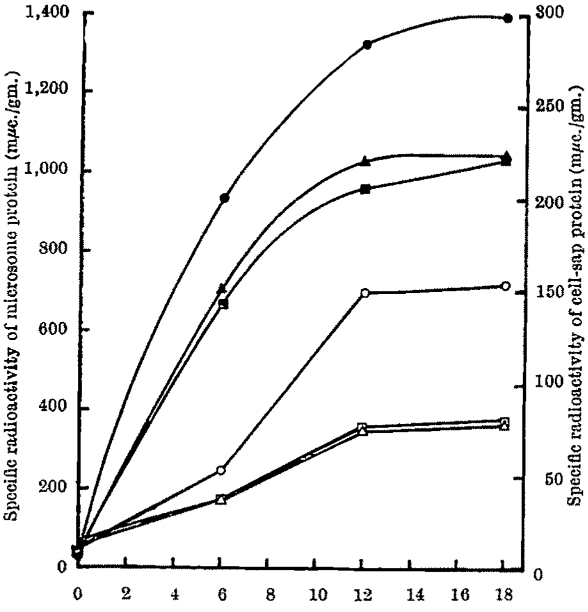

Fig. 1. Incorporation of L-[^{14}C]phenylalanine into protein by cell-free preparations from vitamin B_{12}-deficient and control rats
●, Microsome protein, control group; ▲, microsome protein, deficient group – cyanocobalamin; ■, microsome protein, deficient group + cyanocobalamin; ○, cell-sap protein, control group; △, cell-sap protein, deficient group – cyanocobalamin; □, cell-sap protein, deficient group + cyanocobalamin

Table 3. EFFECT OF VITAMIN B_{12} AND GLUTATHIONE ON THE INCORPORATION OF L-[^{14}C]PHENYLALANINE INTO THE PROTEIN OF MICROSOME AND CELL-SAP FRACTIONS OF LIVER BY A CELL-FREE SYSTEM (EXPERIMENT NO. 6)

Incubation time was 20 min. The animals (see Table 1) were used without previous fasting. Results are mean values of duplicate flasks, except in the case of the non-incubated flasks; individual results differed from the mean by less than 5 per cent

Source of liver	Addition to flasks	Specific radioactivity (mμc./gm.) Microsome protein	Cell-sap protein
Deficient rats	None	1,343	102
	Cyanocobalamin (0·5 μgm.)	1,354	93
	Glutathione (2·4 mgm.)	1,492	125
	Cyanocobalamin (0·5 μgm.) + glutathione (2·4 mgm.)	1,439	109
	None*	29	15
Control rats	None	1,341	99
	None*	20	13

* Flask kept at 0° C.

The experiments with liver minces indicate that the incorporation of amino-acids into protein was less in livers of vitamin B_{12}-deficient rats than in those of control animals. Factors such as the size of the free amino-acid pool can, however, influence the rate of incorporation of labelled amino-acids into protein. The greatest difference was found in protein of the medium, which would be compatible with a decrease in protein secretion rather than in protein synthesis in vitamin B_{12} deficiency. There is, however, no indication that addition of the vitamin stimulates incorporation appreciably. Moreover, the experiments with cell-free systems failed to confirm the reported stimulation of protein synthesis by addition of vitamin B_{12} *in vitro*[3].

While our results do not exclude the possibility that vitamin B_{12} deficiency may result in decreased protein synthesis, they suggest that such an effect is secondary to some other biochemical function of the vitamin.

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LETTERS TO THE EDITORS

GEOPHYSICS

Two Atmospheric Effects in the Orbital Acceleration of Artificial Satellites

As I first pointed out[1], the orbital acceleration of artificial Earth satellites shows fluctuations which cannot be explained on gravitational grounds. In satellite 1957 β 1, these oscillations were rather irregular, although cycles of 19 and 37 days could be discerned[2,3]. According to E. C. Cornford[4], a periodicity of about 25 days was indicated, and this gave rise to speculations about possible tidal effects from the Moon. The same hypothesis was tentatively advanced by D. G. King-Hele[5] to explain oscillations with a period of 27 days in satellite 1958 δ 1. Earlier[3], in collaboration with R. E. Briggs, I had found oscillations with a period of about 30 days in satellite 1958 β 2, but had rejected the tidal hypothesis in view of the many observed irregularities and also because lunar tides should result in oscillations with about half the observed period. It was suggested, rather, that the rotation of the Sun, which has a synodic period of 27 days, could be responsible for changes in upper-atmosphere densities through variable radiation.

The oscillations in the orbital acceleration of 1958 δ 1 were quite regular, much more so than in 1957 β 1. Their period, as derived from 5 cycles, was 29 days, and their semi-amplitude was about 10 per cent of the mean acceleration (that is, the amplitude of the waves increased as the acceleration increased with the spiralling in of the satellite). The most remarkable feature of these oscillations, however, was that they were in phase with those of 1958 β 2, as can be seen from Fig. 1. Accurate acceleration data are not available, at present, for satellites 1958 α and 1958 ε, but a qualitative inspection of the available material (Whitney, C. A., private communication) has revealed that their accelerations, too, oscillated in phase with those of 1958 β 2 and 1958 δ 1. Moreover, accelerations obtained by Siry[6] and Whitney[7] for satellite 1958 γ give a maximum at about April 7 and a minimum near April 22, in close agreement with a maximum and a minimum on the curve for 1958 β 2. It appears rather evident that we are dealing with a global effect—a rhythmic pulsation of the atmosphere as a whole. Since the relative amplitude of the oscillations is much greater for the high-orbiting satellite 1958 β 2 than for the other, lower, satellites, it appears that the amplitude of the atmospheric variations increases with height.

It must be admitted that the regularity of the fluctuations in 1958 δ 1 is a little embarrassing for the solar-radiation hypothesis. Also, the period cannot be brought down to 27 days, although a period of 28 days fits the observations well enough (high latitude plages on the Sun could be responsible for a somewhat longer period since the rotation of the sun becomes slower at higher latitudes). A third difficulty consists in the fact that a 27-day periodicity in geomagnetic and ionospheric phenomena often makes its appearance in times of sunspot minima, but generally not in times of maxima—and now we are near a high maximum. In spite of these difficulties, the solar-radiation hypothesis still appears to me, in default of anything better, as the only plausible solution in sight.

Another effect, which is definitely tied to solar radiation, can be detected in satellites 1957 β 1, 1958 β 2, and also in 1958 δ 1. This is a variation of the orbital acceleration with the angular distance ψ of the perigee from the sub-solar point. The acceleration is greater when ψ is smaller, and the relation between the two variables is quite smooth. In particular, there is no discontinuity at the time when the perigee passes from night into daylight or

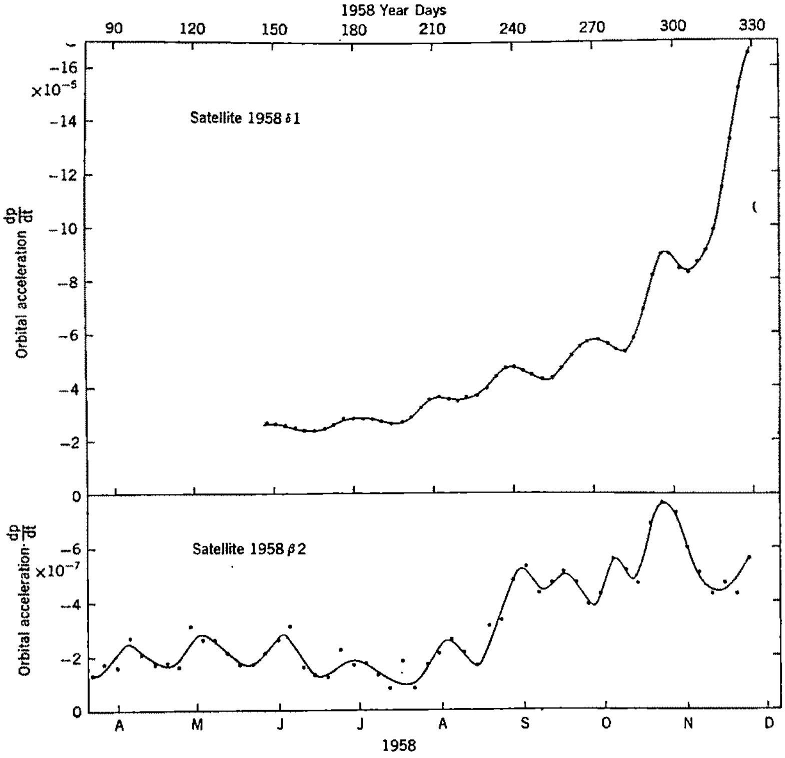

Fig. 1. Comparison of the orbital accelerations of satellites 1958 δ 1 and 1958 β 2 to show the in-phase fluctuations

vice versa, and the relation is quite discernible even in 1958 β 2, for which ψ always varied between 0° and 90° (that is, its perigee was always in the bright hemisphere). There are two possible explanations for this phenomenon. First, it could be due to variable charged drag[8] in an atmosphere in which the ionization decreases with increasing distance from the subsolar point. In this mechanism the satellite acquires a negative charge which will depend on the degree of ionization of the atmosphere, and there will be a supplementary drag caused by the positive ions it attracts from the sides. The second possibility is a real difference in density of the upper atmosphere between the bright and the dark hemispheres of the Earth. Fig. 2 illustrates the effect for satellite 1957 β 1.

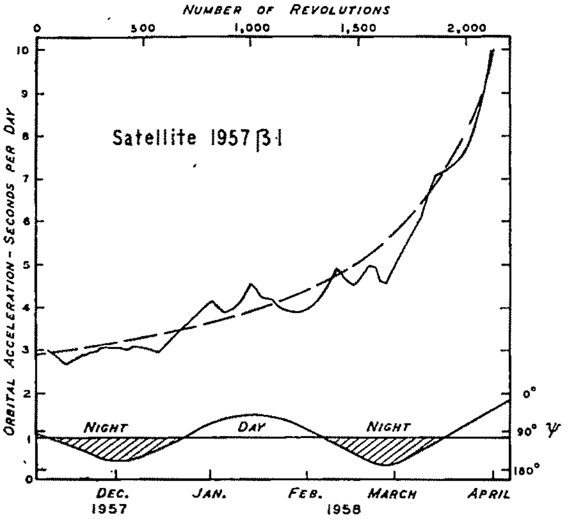

Fig. 2. Orbital accelerations of satellite 1957 β 1 compared with the geocentric angular distance ψ between the Sun and the perigee of the orbit of the satellite

Note added in proof, Jan. 14. In a communication dated Dec. 18, 1958, W. Priester, Universitätssternwarte, Bonn, finds a remarkable similarity between my acceleration curve of 1957 β 1 and the curve of the 20-cm. solar radiation in the interval Nov. 11, 1957–Feb. 10, 1958. Following this hint, I have compared the satellite data with the 10·7-cm. solar radiation data published by the National Research Council, Ottawa, during the period November 1957–December 1958. The correspondence is little short of perfect; there is a suggestion of a 2-day lag in the atmospheric (satellite) curve.

LUIGI G. JACCHIA

Smithsonian Institution Astrophysical
Observatory,
Cambridge, Massachusetts.
Jan. 7.

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Irregularities in the Density of the Upper Atmosphere : Results from Satellites

WHEN an Earth satellite encounters air drag its orbit contracts and its period of revolution T decreases. For most of the satellites so far launched the rate of decrease of T has been irregular, thus implying irregularities in drag, which could be caused by changes in either the effective atmospheric density near perigee or the effective cross-sectional area S of the satellite perpendicular to the direction of motion. If, like most of those so far launched, the satellite does not point in a specific direction but rotates, S is to be taken as the mean cross-section during one complete rotation. The mean cross-section should remain constant as long as the mode of rotation of the satellite is unchanged, though it would not be constant if, for example, tumbling end-over-end changed to spinning like an aeroplane propeller. A clue to the mode of rotation is provided by the fluctuation in brightness of a satellite; if this remains almost the same for many months it is unlikely that the mode of rotation has changed appreciably.

For the rocket of *Sputnik* 3 (1958 δ 1), the rate of decrease of period was particularly erratic[1], but the brightness fluctuated regularly with a period which increased slowly from 8·5 sec. in July to 9·5 sec. in November. This strongly suggests that the mean cross-section did not vary significantly and that irregularities in the rate of decrease of period can be ascribed to variations in atmospheric density. Similar conclusions apply[2] to *Sputnik* 2 (1957 β). For both these satellites the perigee height decreased from 226 km. initially to about 180 km. 10 days before the end of the satellite's life, and any conclusions about air density relate to this height band.

The Royal Aircraft Establishment provided a prediction service for *Sputnik* 3 rocket, and more than 600 observations were received. A preliminary analysis of these has now been made, and the rate of change of nodal period has been calculated at intervals of 3 or 4 days. The results are shown in Fig. 1, in which the great majority of the observed values plotted are believed to be in error by less than 0·1 sec./day. For comparison, a theoretical curve, calculated on the assumption that density is constant from day to day, is also shown in Fig. 1. This curve is derived from the simplest theory, which gives :

$$\frac{dT}{dt} = -\frac{3e_0T_0}{4t_L\sqrt{1 - t/t_L}}$$

where t is time after launch, t_L is the total lifetime, e_0 the initial eccentricity, and T_0 the initial period. In assessing the irregularities in dT/dt, no advantage is gained by using a subtler theory.

The main feature which stands out in Fig. 1, and even more in Fig. 2, where the observed values have been divided by the theoretical, is an oscillation with a period of about 28 days. This oscillation seems more likely to be linked with solar disturbances than with lunar tides in the atmosphere, because the Moon completed one revolution, relative to the perigee of the satellite's orbit, in about 22 days; whereas the Sun rotates, relative to the Earth, once every 27·3 days. The rather sharp onset of the increases in drag, together with the fact that their periodicity agrees better with the solar period than the lunar one,

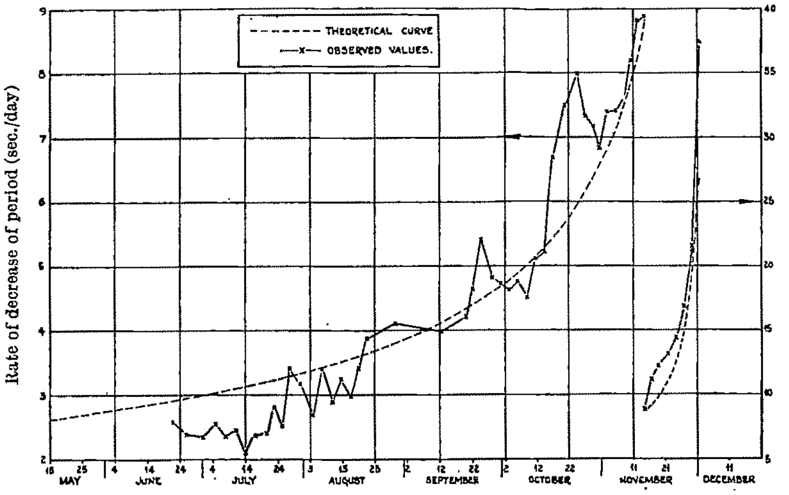

Fig. 1. Rate of change of period for *Sputnik* 3 rocket (1958 δ1)

suggests that the changes in air density are associated with the streams of particles which are projected radially from the Sun and sweep across the Earth at intervals of 27–28 days, giving rise to well-known periodicities in geomagnetic activity[3], cosmic rays and the aurora[4].

Other possible causes of irregularities in air density do not fit in well with the 28-day oscillation. If the movement of perigee from darkness into daylight is an important factor, as suggested by Sedov[5] and Groves[6], there would be an oscillation with a period near 3 months. Figs. 1 and 2 indicate that, though the change in density from day to night may well have some influence, it is not the dominant effect. Another possible source of irregularity is the variation of density with latitude[7]. During the life-time of *Sputnik* 3 rocket, the perigee moved from latitude 50° N. to latitude 20° S. The 28-day periodicity in the values of dT/dt implies maxima of density at intervals of about 10° in latitude. It seems unlikely that the variation of density with latitude should show an oscillatory pattern of this kind, though it cannot be entirely ruled out. It would, however, be surprising to find no variation of density with latitude, and if the irregularities are ignored Fig. 2 might seem to indicate that density increases by about 50 per cent between latitude 40° N. and the equator. The true increase in density is likely to be appreciably less than this, however, since part of the increase is accounted for by the Earth's oblateness, which reduces the height of perigee above the Earth's surface. For the *Sputniks* so far launched, with inclinations near 65°, perigee has taken about a year to make a half-circuit of the Earth, and the increase in the mean value of the quantity plotted in Fig. 2 between latitude 40° N. and the equator can be looked upon as one half-period of the oscillation in dT/dt produced by the periodic change in the latitude of perigee, though some seasonal effect may also be present.

Do the results from other satellites confirm the suggestion that solar disturbances are responsible for the irregularities in air density? For *Sputnik* 1 and its rocket (1957 α 2 and 1) the data available to us are not precise enough for any conclusions to be drawn. With *Sputnik* 2 (1957 β) a somewhat similar periodicity was discernible[2], with maxima of drag occurring about January 20, February 15 and March 15, 1958; and Nonweiler[8] found a significant correlation with solar flares. For *Sputnik* 3 (1958 δ 2), increases in drag occurred about 80, 110 and 140 days after launch, but accurate optical observations have been rather infrequent and the variations have not been accurately determined. For the United States satellite *Explorer* 1 (1958 α), and for *Explorer* 3 (1958 γ), except during its last weeks, perigee crossed the equator at intervals of between 24 and 30 days; the oscillations in dT/dt produced by the periodic change in perigee latitude therefore had a period between 24 and 30 days[9], and, in the present state of knowledge, cannot be reliably distinguished from solar influences of similar period. With *Vanguard* 1 (1958 β 2) somewhat irregular oscillations with [a period near 30 days have been observed and tentatively ascribed[10] to solar influences. Our information on *Explorer* 4 (1958 ε) is limited, but its drag, like that of *Sputnik* 3 rocket (Fig. 2), increased sharply about August 22, 1958, and decreased about September 8.

Thus, it appears that irregularities in air density, especially at heights between 180 and 225 km., tend to recur at intervals of about 28 days, and that this periodicity may well be related to solar disturbances. Variations in density from day to night and with latitude appear to be rather less important. These conclusions must, however, at present be regarded

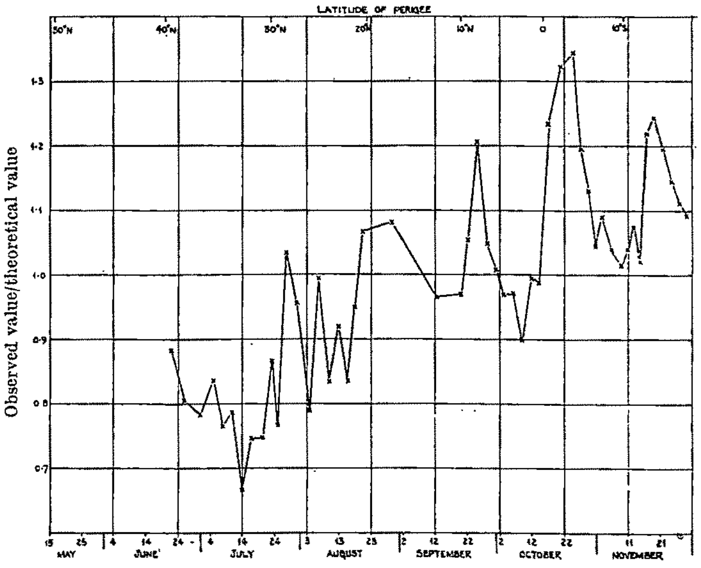

Fig. 2. Rate of change of period of *Sputnik* 3 rocket (1958 δ1). Ratio of observed values to theoretical

as somewhat speculative; there is need for data from further satellites and for a more thorough analysis of existing results.

D. G. King-Hele
D. M. C. Walker

Royal Aircraft Establishment,
Farnborough,
Hants.
Jan. 21.

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Natural Magnetic Moments of Two Chondritic Meteorites

Most of the secondary or chondritic meteorites are composed of irregular grains of silicate, sulphide, phosphide, oxide and metal phases. They are generally thought to be fragments of secondary meteorite bodies which were themselves accumulations of debris from disrupted primary bodies. The process of compaction of the secondary bodies does not appear to have been accompanied by sufficient heating to have melted any of the constituent phases[1,2], which leads to the general conclusion that these secondary bodies did not have fluid, conducting cores capable of producing terrestrial-type magnetic fields, as is possible in the primary meteorite bodies[3]. This implies that alignment of magnetic particles or induction of thermo-remanent or chemical magnetization is unlikely to have occurred in the secondary bodies and therefore that the chondritic meteorites would not be expected to have magnetic moments other than those acquired on the Earth.

We have found substantial natural magnetic moments in the three chondrites which have been examined and have used two of them (Homestead and Mount Browne) in thermal demagnetization experiments to obtain information about the origin of their moments. The Homestead meteorite is a polymict, brecciated grey bronzite-chondrite[4], and a preliminary modal analysis indicates the magnetic constituents to be 1 per cent magnetite and 9 per cent metal by weight. The Mount Browne chondrite is very similar but with a higher proportion of metal, 19–34 per cent[5]. Samples of about 35 gm. were taken from parts of each of these meteorites, more than 3 cm. below the fused crusts, so that the samples could not have been heated above about 100° C. during ablation in the Earth's atmosphere[6]. Both meteorites were observed falls and no obvious oxidation of the metal phases has occurred in the samples examined.

The magnetic moments were measured in a spinner-magnetometer[7] simultaneously with heating to 800° C. in a nitrogen atmosphere. Each of the thermal demagnetization curves revealed three constituent magnetic moments not obviously related in direction; the differences in their directions were of considerable use in distinguishing them.

(1) The low-temperature moment disappeared at 100° C. in Homestead and 90° C. in Mount Browne. This moment was probably acquired after arrival on the Earth, apparently having been induced by a field comparable with that of the Earth in conjunction with possible heating to a temperature not greater than 100° C.

(2) The medium-temperature component behaved in much the same way as the natural moments of magnetically stable igneous rocks, several of which have also been examined with the magnetometer. This component is largely associated with the magnetite grains, although it finally disappeared at 630° C., some 50° C. higher than the Curie point of magnetite, indicating incomplete distinction from (3).

(3) The high-temperature component had a direction clearly different from (2) and disappeared at 775° C., approximately the transformation temperature of the metal phase (Parry, L. G., private communication).

The difference in character between components (2) and (3) was clarified by repeating the demagnetization measurements after the meteorite samples had been exposed isothermally to a field of 15,000 oersteds and also after cooling from 850° C. in a steady field of 10 oersteds. In each case component (3) appeared in the same direction as in the natural state, but (1) and (2) (no longer distinguishable) were in the direction of the inducing field, at a wide angle from (3). This unexpected and anomalous behaviour of component (3) is difficult to explain. It may be due to strongly anisotropic metallic grains from which a plane of layering might be inferred.

For the present purpose component (2) is the most useful one. For the Mount Browne sample this component has been vectorially subtracted from component (3) and displayed as a function of temperature in Fig. 1 for the three cases of natural

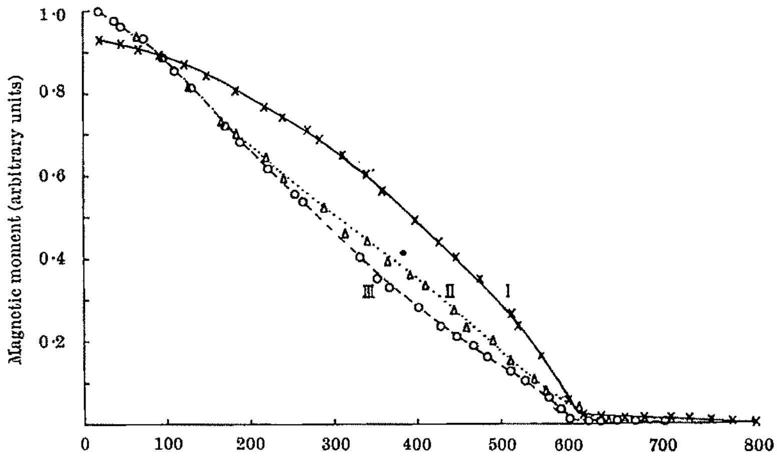

Fig. 1. Thermal demagnetization of Mount Browne chondrite. I, Artificial thermo-remanent moment; II, medium-temperature component of natural moment; III, isothermally induced moment. Curves normalized to coincide at 90° C.

moment (curve II), moment induced isothermally by 15,000 oersteds (curve III), and thermally by cooling in 10 oersteds (curve I). The curves have been normalized to coincide at 90° C.

Since curve III represents thermal demagnetization after saturation, moments induced isothermally by smaller fields would be less resistant to demagnetization and give curves lying below this. The fact that curve II lies above it suggests that the natural moment was induced either thermally or during the course of chemical or phase changes or grain growths, to which the general term chemical magnetization applies. Agreement with curve I, representing the artificial thermoremanent moment, is not very close, so that the natural moment may be due to chemical magnetization; it is known that the latter resists demagnetization more strongly than isothermally induced magnetism but less strongly than thermally induced magnetism[8].

Since it is evident that the chondrites have not been substantially heated or chemically changed after their arrival on the Earth, and that they have thermo-remanent or chemical magnetization, their natural moments must have been induced by extra-terrestrial fields. Also, components (1) and (2) of the natural moments are different, not by virtue of different magnetic constituents in the meteorites but by their having been induced in different fields, (1) being superimposed after (2) was established. Component (1) is evidently terrestrial in origin and component (2) apparently extra-terrestial.

It seems likely that the required extra-terrestrial fields originated in the secondary meteorite bodies themselves. Either these bodies had fluid conducting cores, contrary to the usual conception of them, or else fluid cores are not necessary for the generation of magnetic fields of terrestrial type. A choice between these alternatives may be made when we know whether the Moon has a magnetic field, since it is highly unlikely that the Moon has a fluid conducting core.

F. D. STACEY
J. F. LOVERING

Department of Geophysics,
Australian National University,
Canberra.
Jan. 15.

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PHYSICS

Correlation of Sedimentation-Rates by Dimensionless Groups

DIMENSIONLESS groups are extensively used for correlating data involving fluid flow. Some of the best-known applications include flow through pipes[1-3], movement of bodies through fluids[2-5] and flow of fluids through porous media[5,6]. It is usual to plot a friction factor, ψ, against Reynolds number or a modification of it, B (say), and the relationship thus obtained is of the form:

$$\psi = \frac{K}{B^N} \qquad (1)$$

in which N and K are parameters.

The initial stages in the sedimentation of a suspension[5,7] are frequently characterized by a constant settling-rate, and it has been found that a good description of experimental results[8] is provided by:

$$U = U_0 \varepsilon^n \qquad (2)$$

in which U is settling-rate of the suspension; U_0 is settling-rate of the solids at infinite dilution; ε is porosity of suspension, that is, volume fluid per unit volume suspension ($\varepsilon = 1 - C$, where C is volume concentration of solids). Some approximate values for the parameter, n, are 4·7–5 for streamline flow for spheres, 2·4 for turbulent flow for spheres and 7–10 for rough particles.

If plug flow is assumed to account for the constant settling-rate, by forming force balance equations and using dimensionless groups, it can be shown that:

$$\psi = \frac{\varepsilon^2}{U^2 S}\,\frac{\sigma - \rho}{\rho}\,g \qquad (3)$$

$$B = \frac{U\rho}{(1 - \varepsilon)S\eta} \qquad (4)$$

in which S is specific surface area of solid per unit volume; η is absolute viscosity of fluid phase; σ, ρ are density of solid and fluid phases respectively.

The remaining symbols have their usual meaning and, in equation 4, B is called the Blake or modified Reynolds number. The theoretical model used is perhaps the simplest description of sedimentation, though two refinements were introduced into the derivation of equations 3 and 4. These were: (*a*) the velocity of flow in the interstices of the suspension (U/ε) was used instead of the sedimentation-rate, and (*b*) in place of the usual mean particle diameter, equivalent hydraulic radius of the bed was employed. Consequently, equations 3 and 4 are similar to (and could be considered as extensions of) the Blake–Carman correlation[5,6] for the flow of fluids through porous media. In this, $N = 1$ for laminar flow and equation 1 reduces to Kozeny's equation[5,6], in which $K \simeq 5$. For spheres the equation holds over the porosity-range of approximately 0·4–0·55.

If the relationship between equations 1, 2, 3 and 4 is examined, it can be shown that when $n = 5$ (the approximate value for streamline flow for spheres) and as ε decreases from 0·8 to 0·7, then N increases from 0·9 to 1·1, while K remains almost constant at 4·8. These values for N and K compare favourably with the constants of Kozeny's equation, which is of interest in view of the lower range of porosity for which this equation holds.

Whitmore[9] has reported measurements of sedimentation-rates with two sets of spherical particles. He found $n \simeq 4 \cdot 8$, and though the results are somewhat limited, correlating them with equations 3 and 4 shows that when $\varepsilon = 0 \cdot 75$ and $0 \cdot 80$ then $N = 1$ and $K = 5 \cdot 5$. The value of N remained constant at all porosities, but K increased with porosity, ranging from 6 when $\varepsilon = 0 \cdot 85$ to $13 \cdot 5$ when $\varepsilon = 0 \cdot 95$. This trend may be attributed to departure from plug-flow conditions, which will tend to become more serious as porosity increases. Further work on the sedimentation-rate of spherical particles has been reported by Richardson and Zaki[10], who found $n \simeq 4 \cdot 7$–5. Consequently, a correlation by equations 3 and 4 could be expected.

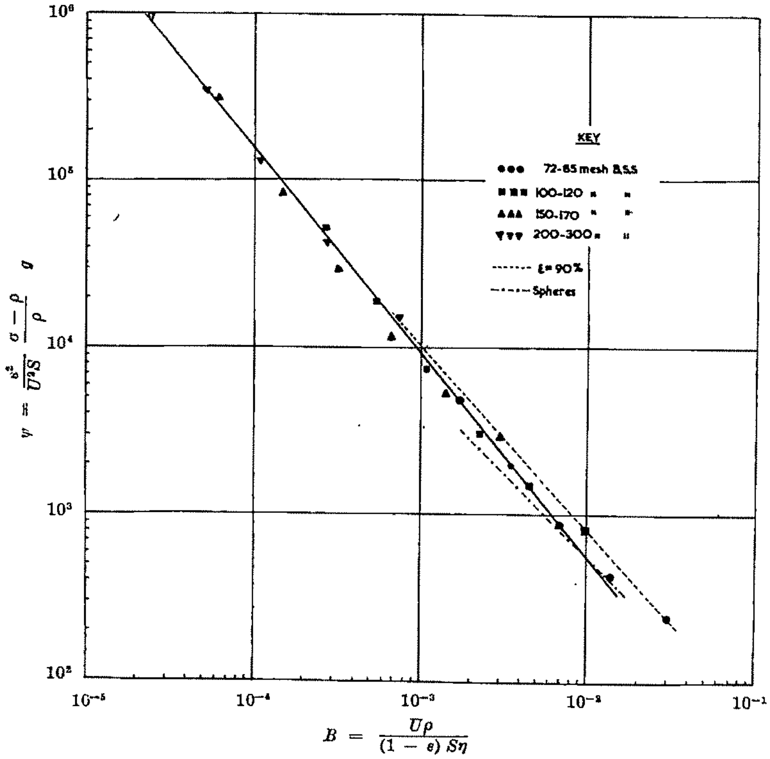

Fig. 1. Sedimentation of rough particles; relation between friction factor and Blake number

Particle shapes other than spherical introduce complications, and shape factors are generally employed to take account of this. However, results obtained by Whitmore[8] for four graded sizes of rough methyl methacrylate powders and correlated according to equations 3 and 4 are shown in Fig. 1. Values of surface area were calculated from the mean particle diameter assuming spheres or cubes, and are probably somewhat smaller than the true values. Thus, if the shape factor is independent of particle size, the true correlation would differ from that shown in Fig. 1 in only one detail, namely, the slope and the relationship of the points to each other would remain unchanged but K would be diminished. In the correlation, $N \simeq 1 \cdot 2$, which is not unexpected because $n \simeq 7-9 \cdot 5$, as compared with $4 \cdot 8$ for spheres. The points representing low concentrations of solids again diverge from the general trend but not in such a pronounced manner as with spheres. This may be because rough particles interlock more readily than spheres and as a consequence conditions of plug-flow may still persist at reduced concentrations.

The scope of this method of representation is yet to be investigated, especially with regard to the shape and effective size of the particle. Two important cases are flocculation and the apparent diameter of rough particles carrying fluid on their surfaces. A further possible investigation, which might be of interest, follows from the similarity between the present and the Blake–Carman correlation which would enable the transition from fluid flow through porous media into sedimentation to be followed on a single diagram. This could be considered to be a function of increasing porosity.

It is believed that equations 3 and 4 have not been proposed before, which is somewhat surprising in view of the widespread application of other similar correlations. In connexion with this, Dr. J. F. Richardson (private communication) has pointed out that Minz[11] employed dimensionless groups for dealing with sedimentation-rates; Minz employed the Blake–Carman correlation directly and worked in the Blake number range 0·1–100, where transition from laminar to turbulent flow takes place. He found that when $B = 1$, $N = 0 \cdot 95$ and $\psi \simeq 5$. Consequently, $K \simeq 5$, which compares favourably with the results obtained here.

Finally, it is possible to raise objections to the use of dimensionless methods to describe flow through porous media, since the method is based upon an assumption of dynamic and hence geometrical similarity which cannot hold for a system of particles in which geometrical configuration is varied in order to obtain different porosities. Consequently, as Rose[12] points out, the results may be empirical, but "the method is an extremely powerful tool for preliminary examination of a very difficult problem".

I wish to thank Prof. J. T. Whetton for interest and encouragement, and my colleagues, Mr. H. G. Smith, Dr. A. Jowett and Dr. G. D. Lill, for useful discussion, and also Dr. R. L. Whitmore, of the University of Nottingham, and Dr. J. F. Richardson, of the Imperial College of Science and Technology, London, for their comments on an earlier draft of this communication.

COLIN HARRIS

Department of Mining,
University, Leeds 2. Oct. 21.

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Variations in the Value of Reynolds Number at the Transition from Streamline to Turbulent Flow

THE flow of nitrogen through a porous copper disk has been investigated experimentally at mean pressures of 2–80 atm., and the flow of carbon dioxide through the same disk has been investigated up to mean pressures of 50 atm., at room temperature. The difference in pressure across the disk was never

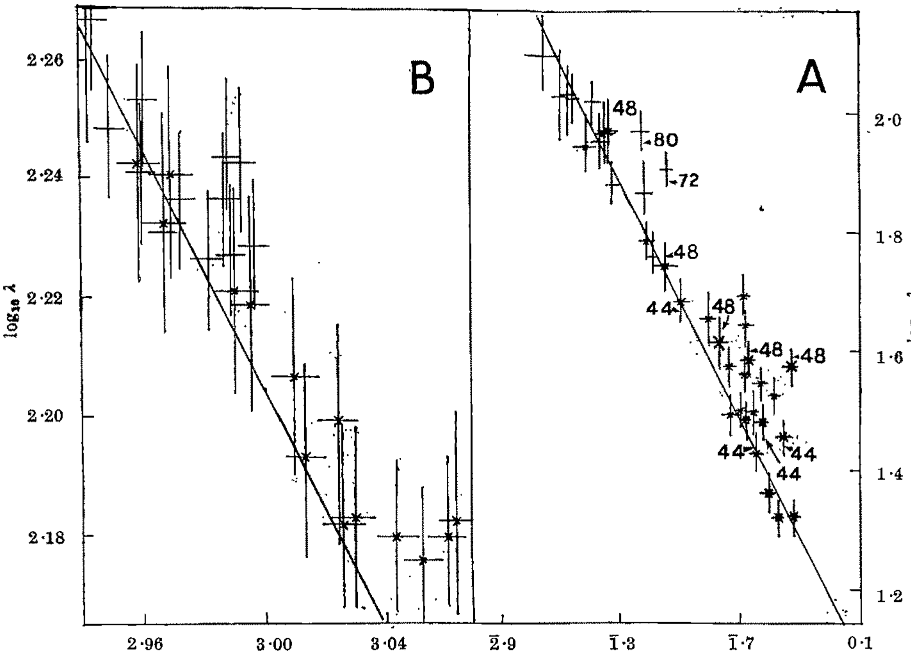

Fig. 1. Graph showing the variation of the friction factor, λ, with the Reynolds number, Re. *A*, For a porous copper disk mean pore radius about 10^{-4} cm. and thickness 0·005 cm.; *B*, for a copper tube about 1 m. long and 0·18 cm. dia. The lengths of the arms represent experimental errors. +, nitrogen; *, carbon dioxide. (Note: The scales are different in the two figures)

more than 0·6 atm. and was as small as 0·2 atm. in some experiments. As the mean pressure was increased from 2 atm. the flow through the disk remained streamline up to mean pressures of nitrogen of about 70 atm. and up to mean pressures of carbon dioxide of about 40 atm., the value of the pressure at which the flow departed from streamline flow being dependent on the pressure difference. Results showing the departure of the flow from streamline flow are given in Fig. 1*A*; some of the mean pressures are shown in Fig. 1 opposite the relevant points; but most pressures have been omitted so as not to confuse the diagram. The straight line represents streamline flow through the disk. Points lying off the straight line are usually attributed to the onset of turbulence; accepting this interpretation if R'_e be the value of the Reynolds number at which turbulence begins then it is apparent from Fig. 1 that (1) R'_e for nitrogen is different from that for carbon dioxide; (2) R'_e for carbon dioxide diminishes as the mean pressure increases.

When the results shown in Fig. 1*A* were first obtained, as an incidental part of a different research programme[1], the results were unusual; but corroborative evidence for variations in the value of Reynolds number at the onset of turbulence has been found since in Lindgren's work[2,3] and in our recent work. Lindgren worked with aqueous solutions of bentonite. He used birefringence to study flow patterns in the solutions as the solutions flowed through a cylindrical glass tube; in addition, he measured drop of pressure occurring in the flow. As the concentration of the bentonite solutions was altered variations were found in the values of Reynolds number at the onset of turbulence which could not be accounted for by changes in the variables occurring in Reynolds number, or by variations in such factors as entry length, which are known to alter the value of Reynolds number at the onset of turbulence.

In our recent work the flow of nitrogen and carbon dioxide at atmospheric pressure through a long copper tube was studied, the pressure difference being about 0·02 atm.; some results are shown in Fig. 1*B*. In Fig. 1*B* the maximum experimental errors are shown, and it is seen that the value of the Reynolds numbers for the onset of turbulence in nitrogen is certainly different from that for the onset of turbulence in carbon dioxide, although the difference is not nearly as marked as it is in the work with the porous copper disk.

In both the tube and the porous disk the values of the Reynolds number at the onset of turbulence are about those quoted for the critical Reynolds numbers for flow in tubes and porous media respectively. That a value for Reynolds number which is so near the value quoted for the critical Reynolds number should vary as the identity of the fluid is altered and also as the pressure is altered in a given fluid suggests a relevant dimension is omitted in the analysis; the temperature is a dimension which is omitted, and it may well be that energy transfer occurs in the gases at what appears to be the transition from streamline to turbulent flow in such a way that the flow is no longer isothermal. But additional experimental and theoretical evidence is required; the problem is: given a piece of apparatus, can the extent of the streamline flow of any compressible fluid in the apparatus be predicted precisely from a series of experiments showing the extent of the streamline flow with one fluid at one given mean pressure?

P. J. Isaac
I. B. Williams
W. M. Jones
Department of Physics, University College,
Aberystwyth.
Jan. 22.

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Effect of Humidity on the Breakdown of a I-cm. Homogeneous Field Spark Gap in Air

The effect of humidity on the breakdown voltage of a homogeneous field spark gap in air has been reported in a previous communication[1]. The increase in voltage with humidity agrees with the results of Ritz[2] and Köhrmann[3] for homogeneous fields, but it is greater than the figure of 0·13 per cent increase per mm. mercury of water found by Lewis[4] for a 0·4-cm.

Table 1. SUMMARY OF BREAKDOWN VOLTAGE MEASUREMENTS ON PLANE ELECTRODES

Author and date		Measured breakdown voltage of 1-cm. gap (kV.)	Conditions		Type of voltage	Breakdown voltage of 1-cm. gap corrected to dryness at 20° C. 760 mm.
Schumann	1922	31·7	Wet, humidity unknown	20° C.	a.c.	30·8*
Klemm	1923	31·4	About 40 per cent humidity (~ 6·9 gm./cu.m.)	20° C.	a.c.	30·5
Spath	1923	31·55	Wet, humidity unknown	20° C.	a.c.	30·6*
Holzer	1932	31·66	Between 30–80 per cent humidity (~ 5·2–13·8 gm./cu.m.)	20° C.	a.c.	30·9–30·4
Ritz	1932	31·35	Wet, humidity 10 mm. (~ 9·8 gm./cu.m.)	20° C.	a.c.	30·3†
Fisher	1947	30·1	Dry	22° C.	d.c.	30·3
Bruce	1947	30·3	Humidity unknown	20° C.	a.c.	29·7‡
Köhrmann	1956	30·1	Dry	20° C.	d.c.	30·1
Present	1958	—	Dry	20° C.	d.c.	29·9–30·3

* Voltage obtained assuming 40 per cent humidity, but it may be more than this, with the result that the voltage will be even lower From the relative humidity data for Jena (1923) prepared by the Meteorological Office this figure appears to be rather low and a better value may be of the order of 70 per cent humidity.

† This value is obtained from Ritz's work on the humidity correction and it agrees with our value.

‡ Assuming 4 mm. of water vapour.

gap between 2-cm. diam. spheres. It is important to know the actual breakdown voltage of a 1-cm. gap not only from the point of view of attempting to understand the mechanism of a spark but also from the more practical application in high-voltage engineering.

For the purpose of comparison a summary of breakdown voltage measurements for plane electrodes obtained by different workers is given in Table 1. The first column gives the author and date of the publication and the second column the observed breakdown voltage. The third column shows the humidity and temperature conditions of the air, while the fourth and fifth columns specify the type of voltage applied, a.c. or d.c., and the breakdown voltage corrected for humidity and a temperature of 20° C.

The differences between the measurements of column 2 made by the early German workers and the later values are almost ± 2·5 per cent about a mean, and it is difficult to account for these differences purely on grounds of errors in voltage measurements. It must be remembered, however, that little attention was paid to the effect of humidity on the breakdown value before the work of Ritz. Klemm[5] indicated that the humidity was about 40 per cent, Schumann[6] and Spath[7] did not consider it, and Holzer[8] mentioned that the humidity was between 30 and 80 per cent. By using our measured increase of voltage with humidity and assuming a figure of 40 per cent for Schumann and Spath, the corrected values are 30·8 kV. for the former and 30·6 kV. for the latter. Holzer's value for the breakdown voltage is reduced to 30·9 kV. for an assumed humidity of 30 per cent and 30·4 kV. for 80 per cent. Ritz's result is reduced to 30·3 kV. when corrected for 10 mm. of water vapour. Fisher's[9] value for the breakdown of a 1-cm. uniform field gap in dry air has also to be corrected for temperature since the measurements were normalized to 22° C.

The values of the breakdown voltage measured by us lie between 29·9 and 30·3 kV. in dry air at a pressure of 760 mm. mercury at 20° C. The low values in the region of 29·9 kV. were obtained with brass and aluminium alloy electrodes which had been freshly polished. These values, however, increased rapidly to about 30·1 kV. with a little sparking and may be attributed to the formation of oxide layers on the cathode. Another 'conditioning' effect which increased the minimum breakdown from 30·1 to 30·3 kV. was most likely due to changes in the gas, and is noticeable in the present work due to the fact that the electrodes were mounted in an enclosed chamber. The absolute accuracy of the present work is about ± 0·5 per cent and the more stable value of 30·3 kV. agrees reasonably well with the corrected values given in column 5 of the table. Examination of these corrected results shows that all the values lie within a range of approximately ± 1 per cent about a mean. Furthermore, if the results prior to 1932 are ignored, and the lower breakdown values coresponding to the higher humidity is taken for Holzer's results, then the differences are as low as ± 0·6 per cent. This is much smaller than is indicated by the uncorrected values given in column 2 and can almost be accounted for by experimental errors. These limits are based on the assumption that the figure of 30·3 kV. given by Bruce[10] is for dry air. This seems rather unlikely, and even if the humidity was only 4 mm. mercury, then Bruce's value will be reduced to 29·7 kV. for dry air, the lowest value in the table. However, this value does not differ significantly from the low values found in the present work using freshly polished electrodes.

K. PHILLIPS
K. R. ALLEN
A. REFSUM

Research Department,
Metropolitan-Vickers Electrical Co., Ltd.,
Trafford Park,
Manchester, 17. Jan. 5.

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CHEMISTRY

Stable Configuration of Methyl Groups in Dimethyl Ether

THE internal rotation of a methyl group about its symmetry axis, despite the presence of the group in a great variety of organic molecules, has attracted little attention, probably because experimental methods such as dipole moment measurement, etc., are not available for the elucidation of the problem. In the structural determination of molecules containing methyl groups, each group is often considered as a whole rather than as four separate atoms[1]. However, the determination is not complete, unless the

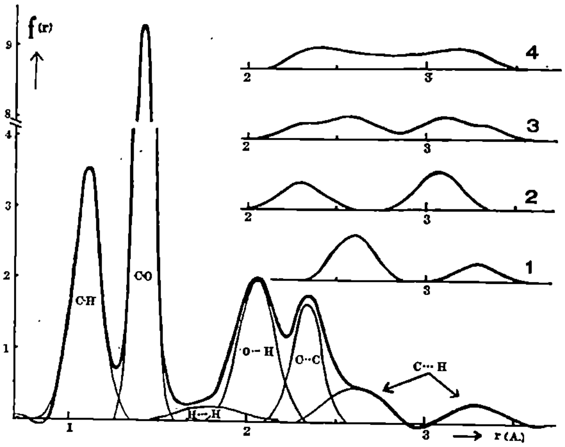

Fig. 1. Experimental radial distribution curve $f(r)$ and the theoretical contributions of C . . . H distances to it for various models

stable configuration of hydrogen atoms in molecules is taken into account. Recent advances in the experimental technique of electron diffraction by gas molecules have made it possible to determine the values of structural parameters with higher precision than formerly. For the present purpose, a dimethyl ether molecule is perhaps the simplest prototype amenable to the sector-microphotometer method in electron diffraction, because the molecule has non-bonded C . . . H distances which are sensitive to the rotation of methyl groups and contribute appreciably to the total scattered intensity.

The electron diffraction photographs were taken with an apparatus[2] having an r^3-sector and a beam trap. Two camera distances, of 12 cm. and 28 cm., were used, the s-region covering 2–12 and 5·5–30, respectively. The conversion of photographic density into total scattered intensity was made by Karle's method[3]. The molecular term of scattered intensity was evaluated by drawing a smooth background through the total intensity curve on the basis of the usual criteria[3], a correction being made for non-nuclear scatterings[4]. In computing the radial distribution curve shown in Fig. 1, theoretical intensity curves for $s < 2$ and $s > 30$ were joined on to the observed curve. No damping factor was used towards the last steps of successive approximations, because the intensity for $s > 30$ was dominated by contributions from bonded C—O distances which could be determined accurately.

The radial distribution curve has two prominent peaks corresponding to bonded C—O and C—H distances. They are isolated and give definite values, 1·416 ± 0·003 A. and 1·094 ± 0·006 A., for the respective atomic distances. Two mutually overlapping peaks can be assigned largely to non-bonded C . . . H distances and a non-bonded C . . . C distance, which leads to a value of 111·5° ± 1·5° for the angle COC. A hump at about 2·6 A. on the right-hand side of the C . . . C peak and a weak peak at 3·3 A. are due solely to contributions from non-bonded C . . . H distances, because the contributions from H . . . H distances between hydrogen atoms belonging to different methyl groups are negligibly small. This gives a clue to the elucidation of the position of the methyl groups relative to the framework. Theoretical curves were therefore calculated for four different models: (1) a model performing restricted rotation about a C_{2v} form as an equilibrium position, with two hydrogen atoms belonging to different methyl groups at the maximum distance apart; (2) the same as (1) except that the two hydrogen atoms are at the minimum distance apart; (3) a model having C_s symmetry, that is, a gear type having a plane of symmetry; and (4) a free-rotation model. These theoretical curves differ from one another to a considerable extent as shown in Fig. 1, and the comparison with the observed curve leads to an unequivocal conclusion that the agreement is best between the experimental curve and the theoretical curve for model 1. One might suspect that the experimental radial distribution curve will be affected by the selection of models, because the theoretical intensity curves were joined on to the observed intensity curve. Examination showed that the experimental radial distribution curve was almost independent of models, on the basis of which the theoretical intensity was calculated for the unobserved s-regions.

In order to confirm the result, theoretical intensity curves were computed for the above-mentioned models with their parameters varied over appropriate ranges and compared with the experimental intensity curve. It was found that the curve for model 1 gave the smallest average deviation of s/s_{exp}. A further check was made by examining the observed intensity at small angles by Morino and Kuchitsu's method[5] for the study of internal rotation. Only model 1 satisfied the required criterion. Hence it is concluded that the internal rotation in this molecule is not free, but that the molecule exerts restricted rotation about the stable configuration having C_{2v} symmetry. Details of this work have been submitted to the *Journal of Chemical Physics*.

KATSUMI KIMURA
MASAJI KUBO

Chemical Department,
Nagoya University,
Chikusa,
Nagoya.

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Catalytic Action of Copper in the Alkaline Autoxidation of Cellulose at Low Alkali Concentration

Bell and Gibson[1] have suggested that the degradation suffered by cellulose in contact with rusting iron is the result of autoxidation catalysed by the iron itself under the alkaline conditions resulting from the process of corrosion. Very little information is available concerning the influence of metals in the autoxidation of cellulose at the low alkali concentrations likely to be involved in such a system. It may therefore be of some interest to describe the results of an investigation in which it was found that copper has apparently an unexpectedly high catalytic effect in the reaction of cellulose with oxygen at low alkalinities.

Small hanks of commercially bleached cotton yarn, soaked in 0·2 M copper sulphate solution, were

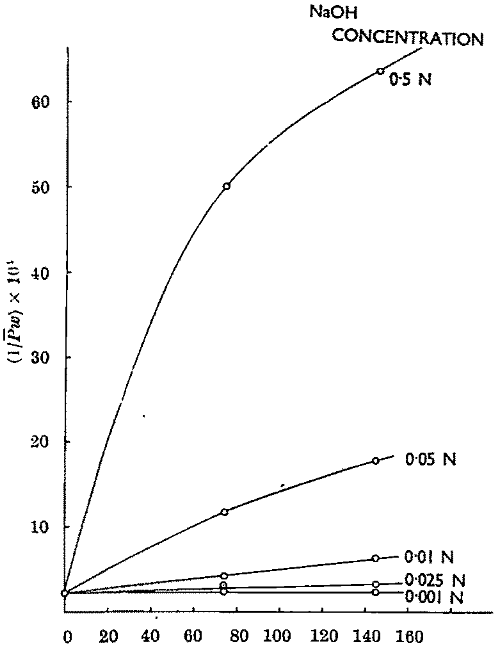

Fig. 1

immersed in sodium hydroxide solution to precipitate the copper, giving a deposit of about 2·5 per cent copper on the yarn. The hanks were then variously conditioned by three immersions of 15 min. each in one of a range of solutions of sodium hydroxide varying in concentration from 0·5 *N* to zero, thus giving a series of specimens containing differing small quantities of free alkali. The hanks were centrifuged, dried and stored in the dark in loosely capped bottles. In additional experiments with cotton containing 'B.D.H.9011' indicator, it was shown that on exposure to the atmosphere the free alkali was converted beyond the stage of carbonate in less than 1¼ hr. even with the highest alkali concentration used.

At intervals the weight–average degrees of polymerization ($\bar{P}w$) of the specimens impregnated with copper were obtained[2,3] from the viscosity in cuprammonium hydroxide solution. Fig. 1 shows the variation of reciprocal $\bar{P}w$ with time. Such a plot gives a direct measure of the reaction-rate provided that the ratio of $\bar{P}w$ to $\bar{P}n$ (the number-average degree of polymerization) remains constant, a condition known to obtain in the heterogeneous acid hydrolysis of cotton[4].

To a first approximation the rate of alkaline autoxidation of cellulose may be taken as proportional[5] to the concentration of sodium hydroxide below 5 *N*. It is accordingly possible to obtain from Davidson's work[6] an estimate of the rate at which alkali-impregnated cotton may be expected to autoxidize without added catalyst at low concentrations of alkali, in terms of the time required to reach a given extent of depolymerization. The rate of degradation observed with 0·05 *N* sodium hydroxide is then found to be greater than that calculated from Davidson's results by a factor of approximately 4 if absorption of carbon dioxide is not taken into account. Assuming conversion to carbonate, the calculated decrease in *p*H corresponds to an increase in catalytic factor to approximately 80, while the true value must be substantially higher than this in view of the inevitable absorption of carbon dioxide beyond the stage of carbonate. Other workers[6,7] concerned with alkali concentrations of 5 *N* or higher have found that less than a ten-fold increase in rate can be brought about by the addition of metals such as iron, cobalt, nickel, manganese or copper. This remarkable difference in catalytic behaviour cannot be accounted for with certainty on the basis of the results at present available. However, one possible explanation is that at high concentrations of alkali, as the concentration of catalyst is increased, the reaction-rate may become dependent on the availability of oxygen and thus eventually independent of the concentration of catalyst (such independence is in fact observed[6,7]). This limitation would be less likely to apply in the present system, where the rates of reaction are relatively low.

R. I. C. Michie
S. M. Neale

College of Science and Technology,
Manchester 1.

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Electron Microscopy of Sodium Laurate

Although a number of papers have been devoted to the electron microscopy of soaps deposited from aqueous solution[1–4], none has reported a study at high resolution. It is the purpose of this communication to discuss some preliminary results of an investigation into the fine structure of sodium laurate using high-resolution electron microscopy and electron diffraction.

Sodium laurate was made from pure lauric acid. Samples for electron microscopy were prepared by allowing a drop of solution to dry down on a carbon-coated electron microscope grid. To minimize thermal damage in the electron beam the specimens were shadow-cast with gold–palladium alloy at an angle of $\tan^{-1}\frac{1}{2}$. Adjustment of the *p*H of the solution to 10·0 made no difference to the structure of the soap.

The form of the deposit varied with the concentration. From solution at low concentration (< 0·02 per cent) the soap crystallized into well-defined needles which at high magnification showed no characteristic substructure. As the concentration was increased beyond about 0·05 per cent a close network of ribbon-like fibres was formed (Fig. 1), the thickness of the ribbon being perpendicular to the substrate. This is in accordance with the findings of other workers. At high magnification these fibres appeared to consist of an array of cylinders or spheres approximately 30 A. in width arranged in lines along the fibre axis (Fig. 2); the periodicity across the fibre was 50–80 A. This regularity of fibre substructure was also shown by sodium laurate dispersed by mulling in *n*-butanol[2] and by carbon replicas of soap fibres dried down on mica. While it is likely that the contrast in the image is due directly to agglomerated particles of shadowing metal, the regularity in the structure indicates that agglomeration on to some unit within the fibre is occurring.

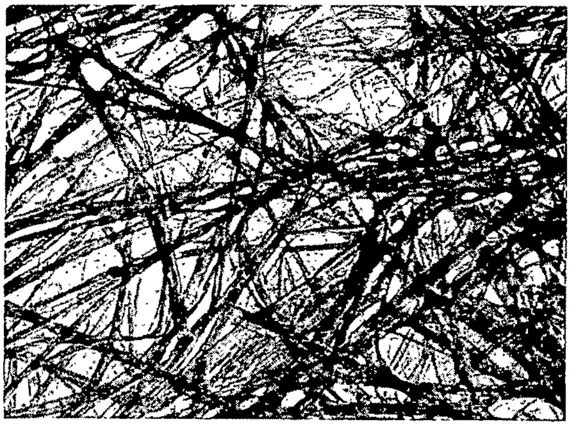

Fig. 1. Low-magnification micrograph of sodium laurate fibres grown from air-dried aqueous solution. (× c. 8,500)

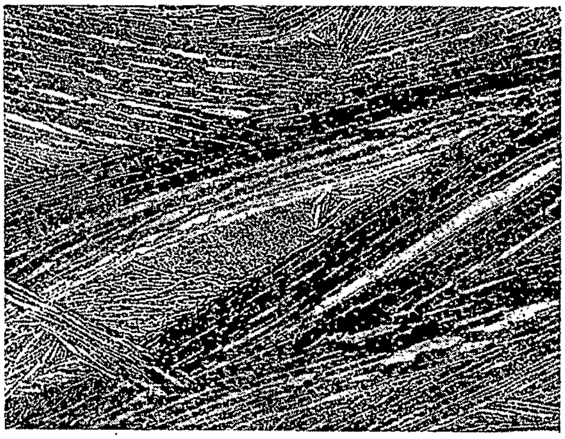

Fig. 2. High-magnification micrograph of part of the same specimen showing the fine structure within the fibres. (× c. 70,000)

It is generally considered[5] that in a soap crystal the molecules are packed with the long chains parallel to the short axis of the crystal, and it has been suggested that in fibres the chains are similarly packed[3]. Using low intensity and low magnification, we have obtained excellent powder patterns corresponding to *hk*0 reflexions only from large areas of both fibre and crystal specimens, which would support the above view that the structures of crystals and fibres are similar.

On the other hand, Bondi and co-workers[6] have proposed an alternative fibre structure in which the chains of the soap molecules are aligned approximately parallel to the width of the ribbon, so explaining the tendency for pure sodium soaps to cleave along the fibre axis. Our electron microscopic observations are more in accord with such a structure. Thus, in Fig. 2, the fibres are made up of ultimate units 30 A. in width (twice the length of a sodium laurate molecule) and the tendency for cleavage, sometimes to fibrils only a few units in width, is clearly illustrated.

We have used selected area electron diffraction of single fibres and crystals in an attempt to resolve this anomaly. Spot patterns of *hk*0 reflexions were obtained from soap crystals, although the crystalline order disappeared rapidly in the electron beam, whereas only diffuse bands were obtained from fibres. It seems possible, therefore, that the large-area diffraction pattern of the fibre specimens was due mainly to a background of sodium laurate crystallites.

The structure of the soap fibres which we have studied thus seems to be different from that of soap crystals, and agrees generally with that proposed by Bondi. As fibres are formed from solution at concentrations well above the critical micelle concentration it is possible that on rapid drying out (as in our work) the micellar character is preserved to some extent in the fibre: the cylinders and spheres which we have observed could be micelles of sodium laurate. Ezaki[7] has proposed a similar structure for fibrous commercial soap. The one technique which could, in theory, resolve this problem—selected-area electron diffraction combined with dark-field microscopy—is not possible under normal conditions of microscopy because of the rapid loss of crystalline order in the fibres. Even large-area diffraction patterns at very low beam intensity disappeared more quickly than those of paraffin wax and fats of much lower melting point. Although the effect cannot, therefore, be due simply to heating, preliminary tests have shown that the fibres are more stable in a cooling stage.

We wish to thank Unilever, Ltd., for permission to publish this work.

T. H. Shuttleworth
M. Camp

Research Department,
Unilever, Ltd.,
Port Sunlight,
Cheshire.
Jan. 22.

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Interaction between Organic Hydroxy Acids and Germanic Acid in Aqueous Solution

A previous communication[1] described the formation in aqueous solution of a number of definite stoichiometric complexes of germanic acid and organic hydroxy acids. These complexes were identified mainly by conductimetric, polarimetric and *p*H measurements. Further work has been carried out on other organic hydroxy acids using the same procedures, and this has resulted in the identification of five more complex acids of germanium. Acids identified are summarized in Table 1.

Crystallization of the complex acids of germanium has proved a difficult task owing to the very high solubility of these compounds in water. Crystalline complex acids in a high state of purity have only

Table. 1

Parent hydroxy acid		Mol. Ge/acid
Glycollic acid	$HO.CH_2.COOH$	1 : 3
Phenyllactic acid	$C_6H_5.(CH_3).C(OH).COOH$	1 : 2
Bromomandelic acid	$C_6H_4Br.CH(OH).COOH$	1 : 3
Benzilic acid	$C_6H_5(C_6H_5).C(OH).COOH$	1 : 2
α-Hydroxy-caprylic acid	$CH_3.CH_2.CH_2.CH_2.CH(OH).COOH$	1 : 2

Table 2

Complex acid	Empirical formula
Germanomandelic acid	$C_{16}H_{20}O_{10}Ge$ (I)
Compound obtained by heating (I) to 140° C.	$C_{16}H_{16}O_8Ge$ (II)
Compound obtained by heating (I) to 190–200° C.	$C_{16}H_{12}O_6Ge$ (III)
Germanobenzilic acid	$C_{28}H_{22}O_7Ge$ (IV)
Germanohydroxycaprylic acid	$C_{16}H_{32}O_8Ge$ (V)
Compound obtained by heating (V) to 150° C.	$C_{16}H_{30}O_7Ge$ (VI)

been obtained when the complexing acid contains a benzene ring or a large number of carbon atoms, for example, mandelic acid, benzilic acid and α-hydroxycaprylic acid.

Results of thermogravimetric and chemical analyses have been combined and empirical formulæ assigned to the crystalline acids (Table 2).

It will be noticed that the three complex acids of germanium and mandelic acid differ from each other by $2H_2O$. The fact that the four molecules of water are given off in two stages seems to indicate that the first two molecules are combined in a different manner from the second two. These observations do not agree with those reported by Mme. O. Vartapetian[2], who did not report any water of crystallization for the complex acid.

A molecule of water of crystallization was found for germanohydroxycaprylic acid, but none for the complex acid derived from germanium and benzilic acid.

E. R. Clark

Department of Applied Science,
Wolverhampton and Staffordshire
College of Technology,
Wolverhampton.

Jan. 21.

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Some Methods for the Purification of Sugar Sulphates

Prompted by the recent publication of a communication on the synthesis and purification of certain sugar sulphates[1], we wish to report on some methods for the preparation and purification of these esters which we have found useful in a wider context.

Sulphation of hexoses, or of methyl glycosides, is usually accomplished by the use of chlorosulphonic acid or of the pyridine–sulphur trioxide complex[2]. We have found the latter reagent to be the more satisfactory if the reaction is carried out at a temperature of 60–70° C. for 9–20 hr., using 3 moles of reagent per mole of sugar. Under these conditions comparable amounts of mono- and di-sulphate are produced, but if one hydroxyl group only is available for sulphation the proportion of reagent can be reduced to 1·5 moles.

The product resulting from the direct sulphation of hexoses and glycosides consists of a mixture of non-sulphated sugar, mono- and di-sulphate. This mixture is difficult to separate by methods of precipitation or fractional crystallization and so our attention was directed towards chromatographic and ion-exchange methods. The successful application of ion-exchange resins in the separation of mixtures of sugar phosphates[3] suggested that this method might be employed for separating sugar sulphates; but a detailed investigation led to the conclusion that, while some separation is possible, the method is tedious and the ultimate yield of pure fractions small.

Lloyd[1] has reported that a satisfactory separation of these mixtures is obtained if the sulphuric acid esters derived from the salts are eluted from cellulose columns using a butan-1-ol/acetic acid/water solvent system. We have also found column chromatography to be of value in this respect. In one method, the mixture obtained by direct sulphation of the sugar (galactose, glucose or mannitol) is adsorbed as the neutral barium salts on a column of cellulose powder (Whatman, Standard Grade, previously washed with water, alcohol and ether and dried at 35° C.). Elution with ethanol/acetic acid/water (80 : 1 : 9 by volume) is continued until the unchanged sugar and monosulphate have been separately removed, and thereafter water is used as solvent to hasten elution of the disulphate. In a typical fractionation by this method, the mixture (5 gm.) obtained by direct sulphation of galactose yielded galactose (0·6 gm.), barium galactose monosulphate $[\alpha]_D^{21} + 33°$ (1·1 gm.), and barium galactose disulphate, $[\alpha]_D^{26} + 38°$ (1·7 gm.), each chromatographically and ionophoretically pure.

In the case of the methyl glycosides of glucose and galactose, the separation of unchanged glycoside from glycoside monosulphate is not so complete, although the glycoside disulphate is readily obtained pure. The separation of the glycoside and the glycoside monosulphate can be effected afterwards by the use of ion-exchange resins. Two columns are connected in series, the first containing 'Zeo-Karb 225' (H^+ form) and the second containing 'De-acidite *F*' (free base). Percolation of the mixture of barium salts through these columns results in absorption of the monosulphate on the anion-exchange resin (second column) from which the unchanged methyl glycoside is removed by washing with water. Subsequent irrigation with 2 *N* ammonium hydroxide elutes the glycoside monosulphate, which is obtained as the ammonium salt by cautious evaporation of the eluate *in vacuo*. Similarly, the mixture obtained by sulphation of 1 : 2-3 : 4 di-O-*iso*propylidene-D-galactose is resolved by ion-exchange resins into unchanged starting material and the ammonium salt of the 6-sulphate.

The technique of partition chromatography using 'Celite' as supporting medium[4] can also be used to resolve mixtures of glycosides and their monosulphates. We have used acid-washed 'Celite 535' (Johns-Manville Co.) as adsorbent with butanol saturated with water as eluting solvent to separate a mixture of α-methyl glucoside and its monosulphate. This method suffers from the disadvantage that the columns have a rather low loading capacity.

For the routine qualitative examination of sulphation mixtures, the method of paper-ionophoresis has the advantages over paper-chromatography of speed and simplicity. A satisfactory resolution of galactose, its monosulphate, and its disulphate is obtained on Whatman No. 54 paper, using 0·067 *M* phosphate buffer (*p*H 6·8) as electrolyte and a potential gradient of 10 volts/cm. for 3–4 hr. Carbohydrate zones are detected by the silver nitrate reagent of Trevelyan, Procter and Harrison[5]. Similar results are obtained with other sulphation mixtures, but the method is not capable of separating two monosulphates.

We wish to thank Prof. Stanley Peat for his advice and the National University of Ireland for the award of a travelling studentship to one of us (M. J. C.).

J. R. Turvey
M. J. Clancy

Chemistry Department,
University College of North Wales,
Bangor.
Jan. 21.

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SOIL SCIENCE

Stability of Soil Crumbs

Tiulin[1] showed that the stability of soil crumbs in water is greater from grassland than from corresponding arable soils. Since then, much work has been done to find out how this increase in stability is brought about by the soil organic matter. A review of this work is given by Baver[2]. In recent years it has been discovered that small additions to the soil of various synthetic polymers, called soil conditioners, also stabilize soil crumbs. The polymers can be either non-ionic, such as polyvinyl alcohol[3], or carboxylated polymers, such as polyacrylic acid[4].

It is now suggested that both soil organic matter and soil conditioners increase the stability of soil crumbs by linking together the principal constituents of the crumbs, the domains of orientated clay and the quartz particles. The linkages will be from the surfaces of the quartz to either the external basal or external edge surfaces of the clay domains, forming inter-crystalline or peripheral complexes[5,6] respectively (Fig. 1).

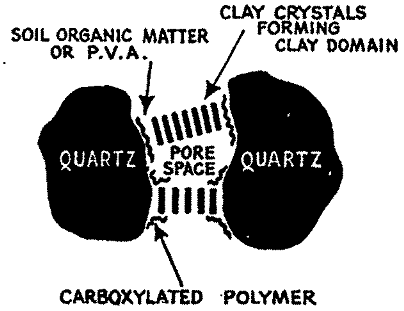
CLAY CRYSTALS FORMING CLAY DOMAIN
SOIL ORGANIC MATTER OR P.V.A.
QUARTZ
PORE SPACE
QUARTZ
CARBOXYLATED POLYMER

Fig. 1. P.V.A., polyvinyl alcohol

The model proposed satisfies the following known features of soil-crumb behaviour.

(1) The arrangement of the soil matrix is the same in both arable and grassland crumbs, both kinds of crumbs yielding similar thin sections[7] and similar moisture-release curves[8]. Untreated and conditioner-treated crumbs also give similar moisture-release curves[9]. (2) The crystalline water uptake and, therefore, the crystalline swelling of the clay is the same in arable and grassland crumbs, as well as crumbs stabilized by a carboxylated polymer[7]. (3) Slaking of the grassland or of conditioner-treated crumbs is reduced[10], for the stresses set up on wetting a dry crumb due to the crystalline swelling of the clay will be shared between several clay domains, through their linkages to the same quartz particles. (4) If the clay is sodium-saturated, the diffuse double-layer swelling is reduced sufficiently by the proposed quartz–organic material–clay linkages to prevent dispersion of the grassland or conditioner-treated crumbs in water[11]. (5) Remoulding grassland or conditioner-treated crumbs by breaking further quartz–clay linkages reduces the strength of the crumbs as measured by any conventional wet sieving or dispersion technique[12].

The model also offers a satisfactory way of accounting for the physical action and economy of soil conditioners. When a solution of a soil conditioner is added to a dry crumb, the consequent slaking will break the weakest clay–quartz bonds, so producing readily available sites for adsorption of the polymer. These sites are, at the same time, the most advantageous for increasing crumb stability.

The detailed presentation of this model with some of its consequences will be published elsewhere[13]. The model is incomplete, in that the chemistry of the linkage of the organic material to the quartz is not specified. There are other methods of stabilizing crumbs, for example, by using quaternary ammonium salts to inhibit the crystalline swelling of the clay[14].

W. W. Emerson

Division of Soils,
Commonwealth Scientific and
Industrial Research Organization,
Adelaide.
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Latent Interparticle Forces in Clays

Work in colloid science is usually concerned with clays in suspension, where external stresses are negligible. Experimental work in soil mechanics has shown that in consolidated and compacted clays both the existing external effective stress and the stress history are most important in determining soil properties[1,2].

If the pressure of pore water in a saturated clay is zero, the external stress σ_E must be balanced by a net intergranular repulsion σ_I:

$$\sigma_E - \sigma_I = 0 \qquad (1)$$

Fig. 1 shows the virgin consolidation curve *ABCDE* and three rebound curves *BF*, *CG* and *DH* for a clay initially prepared at a high water content. Each point on the virgin consolidation curve and on any rebound curve is an equilibrium point with zero pressure of pore water. At any voids ratio ε_1, σ_E may have any value within a wide range (for example, σ_a, σ_b, σ_c, etc.), the maximum being the virgin consolidation value σ_{NC}. It follows from equation (1)

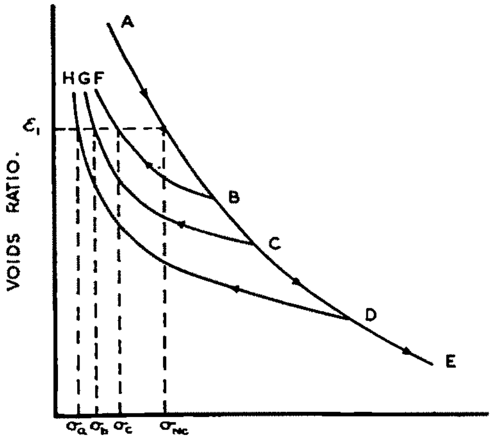

Fig. 1

that σ_I must also have a range of possible values at any voids ratio, with a maximum value $\sigma_{I\max.}$ at the virgin consolidation condition. During rebound the repulsive stress is less than $\sigma_{I\max.}$ so that an additional internal attractive stress σ_{AL} is acting. Equation (1) becomes :

$$\sigma_E - \sigma_{I\max.} + \sigma_{AL} = 0 \qquad (2)$$

At any voids ratio, σ_{AL} will have a maximum possible value $\sigma_{L\max.}$ This is termed the total latent stress. The active portion at any time, σ_{AL}, is the active latent stress and the inactive portion ($\sigma_{L\max.} - \sigma_{AL}$) is the latent stress σ_L.

This attractive stress associated with swelling may arise from particle orientation or from the fact that interparticle forces are not only a function of particle spacing but also of the previous history of particle spacing. Orientation is difficult to support for isotropic consolidation and rebound, and the second possibility is more likely.

In a normally (that is to say, virgin) consolidated clay the latent interparticle forces are completely inactive, and in a heavily prestressed clay they are completely active. In the former case an applied shear stress is resisted by the latent forces becoming active between particles with increasing spacing due to the shear strain, and in the latter case it is resisted by the active latent forces becoming absorbed between particles with decreasing spacing. This leads to a decrease in volume in normally consolidated clays and an increase in volume or dilation in heavily prestressed clays. This behaviour during shear is well known for clays.

Ultimately a unique state is reached, regardless of the initial condition, where the latent forces are fully active between one half of adjacent pairs of particles and completely inactive between the other half. This gives a unique internal and, hence, external stress condition σ_{CVR} for any voids ratio. Experimental evidence for this has been published[3,4].

From the theory of latent interparticle forces it can be shown that the shear strength on an interface is given by the expression :

$$s = \mu(2\sigma_{NC} - 3\sigma_{CVR}) + \mu\sigma_n \qquad (3)$$

where σ_n is the direct effective stress on the interface.

Thus, the strength is composed of two portions : $\mu(2\sigma_{NC} - 3\sigma_{CVR})$, which depends only on voids ratio ; and $\mu\sigma_n$, where μ is an arbitrary constant independent of voids ratio. These portions correspond with Hvorslev's[1] true cohesion and true friction, respectively, but it can be seen from the theory above that these do not represent two different origins of strength. A form of equation (3) suitable for triaxial tests has given excellent agreement with results from Weald clay and London clay.

As latent forces are probably present in all materials which can resist shear stress, it is reasonable to look for their origin in the universal London - van der Waals attractive forces. When two atoms approach each other there may result a mutual disturbance of electron clouds, which is not reversible when separation of the two atoms is again increased. This may result in an attractive force tending to oppose the separation of the atoms.

A discussion of the role of latent interparticle forces in clays will shortly be published elsewhere.

R. H. G. Parry

Soil Mechanics Section,
Commonwealth Scientific and Industrial
Research Organization,
Victoria.
Oct. 29.

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BIOCHEMISTRY, PHYSIOLOGY and MEDICAL SCIENCES

Radiation Protection and Free Radicals

Free radicals formed in biological materials by ionizing radiation may be detected under the proper conditions by paramagnetic resonance techniques. Possibly such free radicals contribute, directly or indirectly, to the radiation damage suffered by living organisms. The various chemicals which have been found to increase the survival of organisms subjected to large doses of radiation may provide protection by action on the free radicals or by some more direct action on the substance of the organism. This report describes experiments made to see if paramagnetic resonance detection of free radicals could be used to study chemical protection against ionizing radiation.

The paramagnetic resonance equipment uses conventional microwave circuitry[1] operating at 9,000 Mc./sec. and dual modulation of the magnetic field[2]. Yeast suspensions were chosen for study because they survive freezing and are easy to handle. β-Mercaptoethylamine was the protective chemical used. Small samples of the material to be examined were quickly frozen after mixing and were irradiated at liquid-nitrogen temperature in a cobalt-60 gamma chamber, then transferred to unirradiated sample tubes for the paramagnetic resonance measurements at 77° K.

On irradiating a suspension of yeast in water, we found the expected doublet resonance due to the irradiated water and a broad line of 25 gauss width near $g = 2{\cdot}00$. An irradiated solution of β-mercaptoethylamine also showed the water doublet and a 25-gauss line at only a slightly higher g-value—too small a difference to distinguish the yeast from the β-mercaptoethylamine with both present. It seemed possible that the width of these lines was a result of

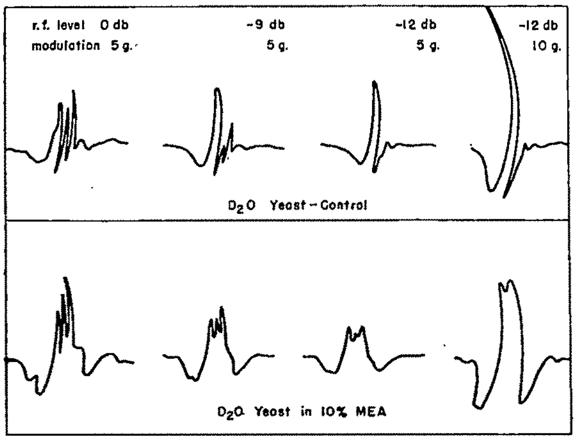

Fig. 1. Saturation effect on yeast signal. Samples Co-60 γ-irradiated 1 hr. at 77° K. for 150,000 r. total dose. Observed at 77° K. MEA, β-mercaptoethylamine; r.f., radio frequency; db, decibels

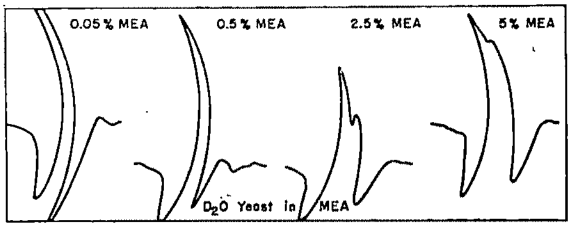

Fig. 2. Effect of β-mercaptoethylamine concentration on yeast and β-mercaptoethylamine signal intensity. MEA, β-mercaptoethylamine. Sample treatment as for Fig. 1

unresolved hyperfine structure due to adjacent hydrogens of the radical. If this were the case, replacing hydrogen with deuterium would narrow the line because the deuteron has a smaller nuclear moment than the proton. We were therefore fortunate in being able to get a generous supply of yeast (*Saccharomyces cerevisiae*) grown in deuterium oxide. (We wish to thank Harry L. Crespi of this Laboratory for the deuterium-grown yeast used in these experiments.) This, when irradiated, gives a signal only 9 gauss wide in addition to the water signal, which is now a triplet (deuteron spin = 1).

Fig. 1 shows how their differing saturation properties may be used for suppressing the water signal and enhancing the yeast signal. In the upper row, beginning on the left with maximum radio-frequency power incident on the sample and the magnetic field modulation adjusted for optimum signal, as the ratio-frequency power is reduced the water triplet is seen to diminish and the yeast line to increase in intensity. The right-hand trace shows an additional increase in the yeast signal by increasing the magnetic field modulation. The lower row shows the same sequence for a sample having 10 per cent by weight β-mercaptoethylamine added before irradiation. On the left is the water triplet sitting on top of the broad β-mercaptoethylamine line. As power is reduced the triplet diminishes, the β-mercaptoethylamine signal remaining constant. On the right, increasing the modulation increases the β-mercaptoethylamine signal. The yeast signal is seen as a small pip on the side of the β-mercaptoethylamine line, indicating, due to the presence of the β-mercaptoethylamine, a decrease in the number of yeast free radicals.

Fig. 2 shows the effect of concentration of β-mercaptoethylamine on both yeast and β-mercaptoethylamine signals. At 0·05 per cent β-mercaptoethylamine the yeast signal is unaffected and the β-mercaptoethylamine signal cannot be seen. Increasing the concentration of β-mercaptoethylamine to 0·5 per cent brings a 10 per cent reduction in the yeast signal and a small indication of the β-mercaptoethylamine on the right side of the trace. At 2·5 per cent β-mercaptoethylamine the yeast signal is reduced by half and the β-mercaptoethylamine signal becomes comparable to it. Increasing the β-mercaptoethylamine to 5 per cent doubles its signal and brings the yeast signal down to 20 per cent or less of its original value. Although not shown in this figure, the water signal is independent of concentration of β-mercaptoethylamine.

From previous work we knew that free radicals produced in water at 77° K. were unstable at 125° K. After annealing at the latter temperature for 1 min., the water signal had disappeared but there was no change in the yeast or β-mercaptoethylamine signals.

We have then: (1) The presence of β-mercaptoethylamine inhibits free radical formation in irradiated yeast. (2) The ½ min. required to add β-mercaptoethylamine to yeast and freeze is time enough for the protection to be established. (3) The β-mercaptoethylamine has no effect on the number of radicals formed in the water of the suspensions. (4) The water radicals, on gaining mobility at 125° K., do not react with the yeast radicals or β-mercaptoethylamine radicals. These observations support the view[4] that the protective effect is not primarily due to inactivation of the products of irradiation of water but rather to direct action of the protective agent on radiosensitive constituents, for example, cell protein.

BERNARD SMALLER
EUGENE C. AVERY

Chemistry Division,
Argonne National Laboratory,
Lemont, Illinois.

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Absence of a Relation between Lipogenesis and Ketogenesis *in vivo*

IN the normal liver acetyl-coenzyme *A* is formed from glucose, fatty acids and the keto-acids produced by deamination and transamination of amino-acids. It is removed by oxidation, by fatty acid synthesis and, to a small extent, by ketone body formation (Fig. 1). Lipogenesis is defective in the livers of diabetic and fasting animals, a block occurring in the path of conversion of acetyl-coenzyme *A* to fatty acids[1]. Formerly, many workers related the development of ketosis to a diminished rate of oxidation of acetyl-coenzyme *A*, due to a possible lowering in the level of oxaloacetate. Lately, as a result of experiments *in vitro*, increased ketogenesis has been attributed to a diversion in the utilization of acetyl-coenzyme *A* (or acetoacetyl-coenzyme *A*) from fatty acid synthesis towards the formation of ketone bodies[2-4]. Stadie[4] has advanced the hypothesis that the supply of reduced triphosphopyridine nucleotide, which depends upon the rate of glucose metabolism via the hexosemonophosphate 'shunt', regulates fatty acid synthesis and, consequently, ketogenesis.

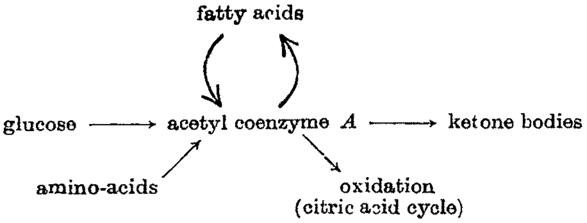

Fig. 1

There is little evidence to show that diminished hepatic lipogenesis is responsible for increased ketogenesis *in vivo*. The lipogenesis theory of ketone-body formation lays emphasis on the under-utilization, rather than on the over-production of acetyl-coenzyme *A* by the liver. However, it is difficult to explain, other than by accelerated oxidation of fatty acids (giving rise to over-production of acetyl-coenzyme *A*), the enormous formation of ketone bodies which is necessary to account for extra hepatic utilization-rates representing 50–96 per cent of the body's oxygen consumption during starvation[5], or for the very heavy ketonuria of severe diabetics[3]. It is difficult to visualize how restoration of the normal rate of hepatic lipogenesis would have more than a moderating influence under these conditions. Since lipogenesis is defective in the livers of animals fed diets devoid of carbohydrate[1], the following experiments with rats on an all-fat diet are relevant to this problem.

Female rats (200 gm.) were fasted for 24 hr. and then given filtered butter-fat *ad libitum* for six days. Experimental details have been published previously[6]. The ketonæmia initiated by starvation continued to rise on feeding fat, but in animals consuming approximately 6 gm. a day a marked reduction was observed after the first day of feeding (Fig. 2). In contrast the ketonæmia of rats which ate less of the diet remained elevated. The ketonæmic responses of animals consuming 6 gm. a day fell into two categories. In one, illustrated by rat *A* (Fig. 2), there was a return to within the normal ketonæmic range, usually on the fifth day of feeding fat. The other, illustrated by rat *B* (Fig. 2), is typical of animals showing a higher initial ketonæmia which dropped afterwards but remained slightly elevated on the fifth day. There was a tendency for the ketonæmia to rise a little in all animals on the sixth day of feeding.

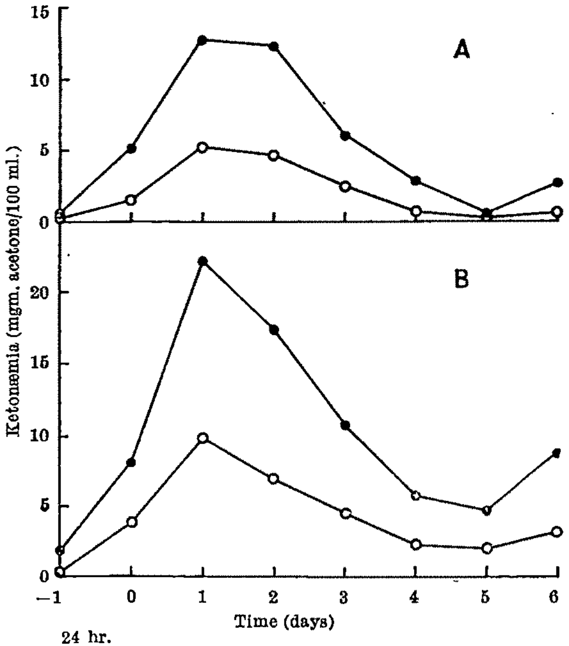

Fig. 2. The course of ketosis in rats starved for 24 hr., which then consumed approximately 6 gm. of butter-fat per day. ●, β-Hydroxybutyric acid; ○, acetone plus acetoacetic acid

The observation of a much reduced ketosis and sometimes its abolition under conditions in which fatty acid synthesis is considered to be defective provides direct evidence that a reduced rate of hepatic lipogenesis is not, necessarily, the major cause of ketosis *in vivo*.

P. A. MAYES

Department of Physiology,
Royal Veterinary College,
London, N.W.1.
Dec. 19.

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Stability of Cholinesterase of the Electric Eel

A CONVENIENT source of the enzyme acetylcholinesterase occurs in the electric organ of the electric eel, and preparations of a high degree of purity have been obtained from it[1]. Because of the high activity of these preparations and the sensitive methods available for the estimation of enzymatic activity, appreciable dilutions of the enzyme must often be made. It has been found that dilution causes a rapid loss of enzymatic activity, and the addition of an inert protective protein such as gelatine has been recommended[1]. Further studies[2] have revealed that low ionic strengths also produce inactivation and that protection is afforded by plasma albumen[3].

Present investigations into this effect have shown that inactivation in dilute enzyme solutions is primarily a surface phenomenon. Because of the obvious importance of this observation in the preparation and estimation of this enzyme, it is felt that this fact should be emphasized.

The sample was one kindly supplied by the U.S. Army Chemical Centre, Edgewood, Md. and had an activity of 46 gm. of acetyl choline/hr./ml. at 37° C., determined manometrically. It contained 3·97 mgm. of protein/ml. in approximately 6 per cent ammonium sulphate. This sample has remained stable and of the same activity over a period of 1½ years when kept at about 3° C. Enzymatic activity was estimated manometrically using the following conditions: 1·5 ml. 0·05 *M* sodium bicarbonate, 0·5 ml. 0·6 *M* sodium chloride, 0·1 ml. 0·6 *M* magnesium chloride, 0·1 ml. 3 per cent bovine plasma albumen, 0·1 ml. 0·3 *M* acetyl choline bromide, an aliquot of the enzyme solution and water to give a final volume of 3·0 ml. The gas phase was 5 per cent carbon dioxide in nitrogen, which gave a *p*H of 7·43 at 37° C.

Stock enzyme solution was diluted 2,000 times in different solutions, and the activity estimated after two different treatments and compared with controls diluted in the same solutions. In one treatment the solutions were shaken in small stoppered tubes for 1 hr. at room temperature, while the other treatment consisted of bubbling nitrogen through the solutions for 30 min.

The diluting mediums were as follows: *a*, 6 per cent ammonium sulphate solutions adjusted to *p*H values of 5·4, 7·4 and 9·0; *b*, 0·1 per cent bovine plasma albumen, or gelatine; *c*, 0·02 *M* veronal buffer of *p*H 7·4 containing 0·3 *M* potassium chloride and 0·1 per cent bovine plasma albumen; and *d*, 0·3 *M* potassium chloride.

The results of both treatments are shown in Table 1.

Table 1. Loss of Enzymatic Activity

Solution	Treatment Nitrogen bubbling (Activity lost, per cent)	Shaking
a	85–97	75–95
b	2	2
c	0	0
d	95	90

It is clear that, in either solutions *a* or *d*, shaking or bubbling by nitrogen rapidly inactivates the enzyme. This inactivation would appear to be a surface phenomenon and not an oxidation process. The dilute control solutions in ammonium sulphate do not show any appreciable loss of activity if care is taken to avoid excessive agitation in their preparation. Protection is afforded to the enzyme by either bovine plasma albumen or gelatine. It is standard practice in this laboratory to make dilutions of acetylcholinesterase in the veronal buffer solution *c* in which the enzyme is stable for 1–2 weeks when kept in the cold.

J. F. Scaife

Defence Research Kingston Laboratory,
P.O. Box 123,
Kingston, Ontario.
Dec. 8.

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Neuromuscular Blocking Agents of Short Duration

For a number of years we have been interested in the neuromuscular blocking properties of *bis*-onium compounds derived from substituted tropane nuclei, in which linking of the quaternary nitrogens was effected by a polymethylene or aralkyl chain. We observed that such compounds produced a flaccid paralysis on injection into chicks but tended to be long acting. This observation led to the preparation of a series of similar compounds (Fig. 1) in which the linking chain contained two ester-groupings as in suxamethonium. The latter is known to produce short-acting block which is, however, of depolarizing character.

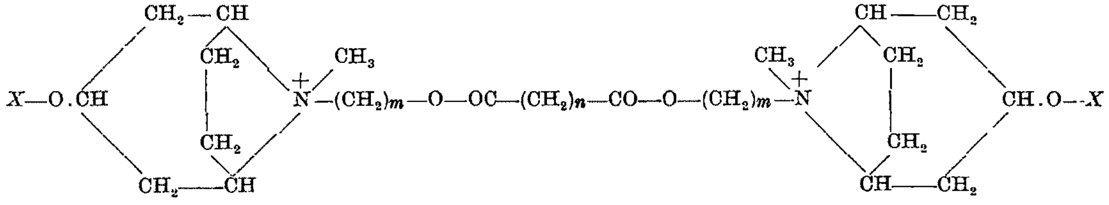
Table 1. Doses of *D.F.* 596 required to produce Paralysis in Different Species

Species	Test	Intravenous dose mgm./kgm. with limits of error ($P=0·05$) *D.F.* 596	*d*-Tubocurarine chloride
Mouse	Dose causing 50 per cent of animals to fall from an almost vertical wire mesh screen within 1 min. of injection	0·23 (0·21–0·25)	0·041 (0·037–0·046)
Rat		0·40 (0·36–0·44)	
Rabbit	Dose causing head drop in 50 per cent of animals after a single rapid injection	0·16 (0·13–0·20)	
	Mean head-drop dose after slow infusion		0·18 (0·15–0·20)
Cat	Mean dose giving 50 per cent depression of gastrocnemius twitch	0·36 (0·28–0·46)	0·2* approx.
Dog		0·089 (0·061–0·117)	0·1 approx.

* Because of the cumulative action of *d*-tubocurarine this value was estimated from the initial dose injected into each animal.

Subsequent tests confirmed that several of the above substances combined the desirable short-acting property of suxamethonium with the competitive blocking action observed in other series of *bis*-tropinium compounds. Duration, potency and effects on blood pressure were found to be determined by the composition of the chain and the terminal acyl radicals. Short duration, low potency and marked hypotensive properties were favoured by high values of *n*, and greatest potency appeared to be associated with chains equivalent to 12 or 13 carbon atoms in length.

One of the most promising members of the series from the point of view of duration and potency was *D.F.* 596 (*X*, phenylacetyl; *n*, 4; *m*, 2). Doses of this compound required to produce paralysis after a single intravenous injection were determined in various species and are given in Table 1. By direct comparison it was found to be slightly more active than *d*-tubocurarine chloride in the dog and about half as potent in the cat. Duration of paralysis was comparable with that of suxamethonium and cumulative effects were not observed. Injection of doses which almost completely abolished the gastrocnemius twitch caused a fall in blood pressure and mydriasis of short duration in cats, but these effects were only slight in dogs. By administering the compound to rabbits as an intravenous infusion, it was possible to obtain head drop and what appeared to be complete recovery four times within 40 min.



X, Acyl radical; *m*, 2–3; *n*, 1–6.

Fig. 1

Neuromuscular block in cats and dogs due to *D.F.* 596 was antagonized by neostigmine, edrophonium, suxamethonium and decamethonium and augmented by ether and *d*-tubocurarine. During partial block the response to a tetanus was poorly maintained. The compound did not cause a contracture of chicken gastrocnemius or frog rectus abdominis muscle but antagonized contractures produced by suxamethonium on the former and by acetylcholine on the latter.

Rabbits anæsthetized with urethane and maintained by artificial ventilation tolerated large doses of the compound ; six animals which received a single intravenous injection of 100 mgm./kgm. were still alive 6 hr. later when ventilation was discontinued. In each case spontaneous respiration returned.

A full account of the work carried out on this and other closely related series will be published elsewhere. Patent applications are pending.

C. G. Haining
R. G. Johnston
J. M. Smith

Duncan, Flockhart Research Laboratories,
Wheatfield Road,
Edinburgh 11.
Dec. 9.

Entropy and Synovial Pathology

Previous *in vitro* experiments on synovial metabolism have shown that the presence of rheumatoid disease in the synovial membrane resulted in marked metabolic changes[1]. The rate of uptake of oxygen was greatly altered by the presence of the disease, for example, normal synovium (of traumatic origin) Qo_2(N) 1·0 up to Qo_2(N) 35·0 in very active disease states. A crude relationship was found to exist between the macroscopic appearance of the pathological material and the rate of uptake of oxygen. As the change in uptake of oxygen was so marked in the rheumatoid synovia, we felt that some quantitative relationship might exist between the rate of uptake of oxygen and the state of the disease. The problem, therefore, was to obtain a quantitative method for expressing the pathological changes in the diseased synovium.

Rheumatoid arthritis is characterized locally by the occurrence of hypertrophy in the synovial and stromal layers, the appearance of round cell foci, plasma cells and to a lesser extent leucocytic infiltration in the subsynovium. The numbers of these various cell types vary greatly in different stages of the disease. Herdan[2] has shown that a quantity H, termed 'entropy' because of its formal similarity with the entropy of statistical mechanics, may be used for expressing changes in the pattern of serum proteins in pathological conditions and, more generally, could be used as a measure of pathological disorder. The entropy of the mixture, H, is calculated as the expression:

$$H = - \Sigma p_i \log_2 p_i$$

where p_i represents the proportion of a constituent. We have applied this expression to the synovial cytology of normal and pathological material. The cellular proportions were obtained by a standardized counting technique, the details of which will be reported in full elsewhere. The error of estimate was found by obtaining 25 separate estimates of H from a typical rheumatoid synovium. For this tissue the mean H was 1·989 and the standard error of the mean 0·023. H was calculated routinely from 10 separate estimates of the cellular counts in a variety of normal and rheumatoid synovia.

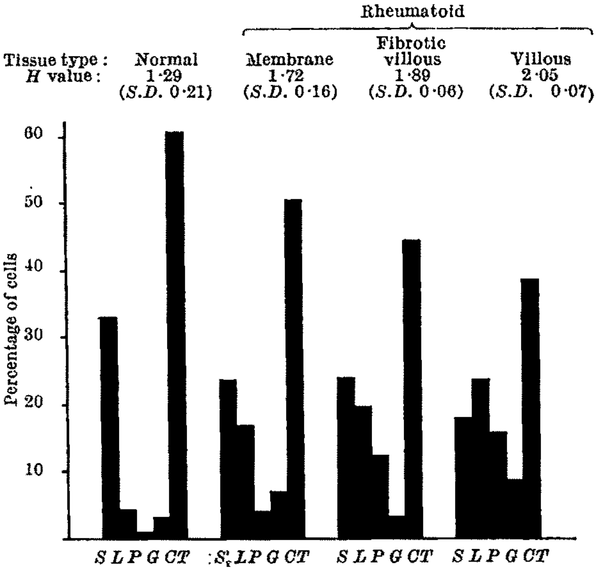


Fig. 1. The distribution of certain cell types in normal and rheumatoid synovia, together with their mean entropy values (H). S, Synovial cells; L, lymphocytes; P, plasma cells; G, granulocytes; CT, connective tissue cells; $S.D.$, standard deviation

Fig. 1 shows the average distribution of certain cell types in normal and rheumatoid synovial tissue. The rheumatoid synovia have been classified macroscopically as previously described by Dingle and Page Thomas[3]. Rheumatoid tissue shows a greater tendency to equidistribution of cell types, which is most marked in the villous material. The mean entropy values H were calculated for each of these distributions, and it may be seen that the value of H rises as the cellular content becomes more abnormal. Fig. 2 shows an application of this result to 19 different rheumatoid synovia of varying metabolic activity. There is a correlation between log Qo_2(N)

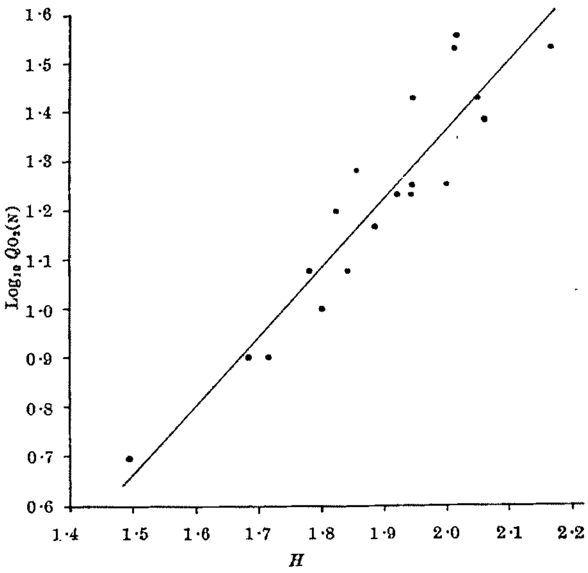


Fig. 2. The correlation of oxygen uptake with 'entropy' value for nineteen rheumatoid synovia

and H over a wide range of metabolic activity. The regression equation is $y = 1{\cdot}38x - 1{\cdot}41$, $r = 0{\cdot}95$, $P < 0{\cdot}001$. Thus it would appear that H can be usefully employed as a criterion of the disease state in terms of the extent of pathological disorder, especially where information is required as to the relationship between the cellular composition and the experimental findings.

D. P. Page Thomas
J. T. Dingle

Rheumatism Research Unit,
Royal National Hospital for Rheumatic Diseases,
Bath.
Dec. 15.

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Distribution of Melanophore-aggregating Hormone in the Pituitary of the Minnow

The melanophore-aggregating hormone of the pituitary of *Gadus callarias*[1] and *Cyprinus carpio*[2] has been shown to be concentrated in the meta-adenohypophysis (pars intermedia). In *Parasilurus asotus* the hormone is concentrated in the meso-adenohypophysis (*Übergangsteil*)[3]. Spinal-sectioned minnows (*Phoxinus phoxinus*) are able to maintain the white background response after hypophysectomy provided some of the anterior part of the pituitary remains after the operation but not if the whole pituitary is removed[4].

In ventral view the minnow pituitary is seen to be divided into an anterior opaque region with few superficial blood vessels, corresponding roughly to the histological divisions of pro- and meso-adenohypophysis, and a less-opaque posterior region with considerable superficial vascularization corresponding roughly with the meta-adenohypophysis (Fig. 1).

Minnows (55–65 mm. long) taken from a stock maintained in a white tank were decapitated and the pituitaries exposed by removal of the floor of the mouth. With the aid of a small piece of razor blade attached to a glass rod, the pituitary was swiftly divided into two portions with a single cut along the line separating the two regions described above ($X - X'$ in Fig. 1). The two portions were removed and separately homogenized in 0·1 ml. of distilled water. The procedure, from decapitation to the separation of the two portions, was completed in 20–30 sec.

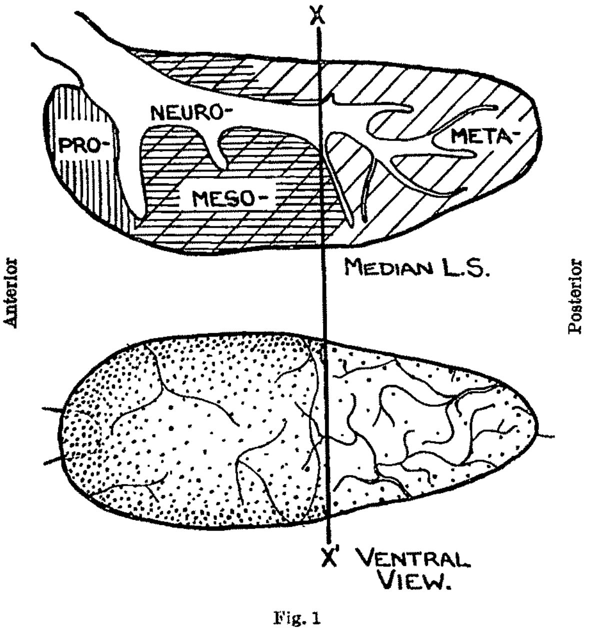

Fig. 1

Table 1

Response of B region melanophores of black-adapted minnows	Pituitary region	
	Anterior	Posterior
Change in melanophore index 1 hr. after injection	0·0	1·2
	0·0	2·6
	1·8	1·4
	0·4	2·8
	0·4	2·0
	1·4	3·0
	0·0	0·4
	1·2	1·0
	0·2	1·4
	2·0	2·6
	0·0	0·4
	2·0	1·8
	0·6	2·8
	0·0	1·4
	0·2	2·6
Mean	0·68	1·83
S.D.	0·777	0·878
	$P < 0{\cdot}01$	

The whole of the homogenate was injected into the body cavity of black-adapted minnows (60–65 mm. long). The melanophore index of the region B micromelanophores[5] of each individual was read immediately prior to injection and again 1 hr. after injection. The results are summarized in Table 1. In 10 out of 15 cases the posterior region of the pituitary showed greater melanophore-aggregating activity than the anterior region, while in five cases the responses were more or less equal.

Of particular interest is the fact that the melanophore-aggregating activity was detectable in both regions of the pituitary. In view of the short period of time elapsing between decapitation of the fish and separation of the two portions of the pituitary (30 sec.) it seems unlikely that appreciable diffusion of the hormone could have occurred. This suggests, in the light of Healey's observations[4], that the melanophore-aggregating hormone is produced in the anterior part of the pituitary and passed to the posterior part for storage.

Enami's observation[3] that the melanophore-aggregating hormone in *Parasilurus* has its origin in the nucleus lateralis tuberis of the hypothalamus suggests that a similar arrangement may occur in the minnow. Experiments aimed at detecting melanophore-aggregating activity in the minnow hypothalamus have been unsuccessful. While this does not preclude the possibility that the hormone is present in amounts too small to detect, it suggests that an alternative explanation may have to be sought to account for the condition in this species. The occurrence of large ganglion cells in the anterior part of the minnow neurohypophysis such as have been described in *Salmo* and *Gadus* and the apparent absence of a nucleus lateralis tuberis indicate a possible extra-hypothalamic source of neurosecretion. It is clear that further evidence is necessary before a final judgment can be made regarding the role of these cells in the production of the melanophore-aggregating hormone. Experiments aimed at obtaining such evidence are now in progress.

Acknowledgments are due to Dr. E. G. Healey for supervision and to the Department of Scientific and Industrial Research for a research scholarship.

A. K. Kent

Department of Zoology,
Bedford College,
University of London.
Dec. 11.

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Gibberellins and Nodulation

Recently, Fletcher, Alcorn and Raymond[1] presented evidence that gibberellins had no effect on the nodulation of white clover (*Trifolium repens*) grown either in aseptic agar or in soil. In concentrations from 1 to 1,000 p.p.m., gibberellic acid was also without effect on the growth of the nodule-forming organism *Rhizobium trifolii*. These combined results seemed to contradict a previous report of Thurber, Douglas and Galston[2], who had found a marked depressive effect of potassium gibberellate on nodulation in dwarf beans (*Phaseolus vulgaris*).

Although I have done no further work on this phenomenon since the original report, I have been in receipt of information from other workers in the field, who have corroborated and extended our findings. For example, Dr. P. W. Brian, of Imperial Chemical Industries, Ltd., has informed me that 10 and 100 p.p.m. sprays of gibberellic acid, applied daily or weekly, greatly depressed the number of nodules and the mean diameter of nodules of 14-day old plants of *P. vulgaris* var. Masterpiece grown in garden soil.

Similarly, Dr. N. P. Kefford, of the Commonwealth Scientific and Industrial Research Organization, Division of Plant Industry, Canberra, has found a depressive effect of gibberellic acid at 0·3 p.p.m. on nodule formation of lucerne (*Medicago sativa*, Hunter River) grown for 42 days on mineral agar, the acid in these experiments being added directly to the agar. In this case, the fewer nodules were each of larger volume than the controls, so that the nodule volume per plant was unaltered by treatment with gibberellic acid. Both Dr. Brian and Dr. Kefford plan to publish their results in detail.

In view of these results, involving independent demonstration of the same kind of phenomenon in three widely separated laboratories, it would seem that the original conclusion that gibberellins can inhibit nodulation is valid, and that some care is therefore required in the use of this product on legumes. It is also clear from the work of Fletcher *et al.* that not all legumes grown under all conditions will show this inhibitory effect of gibberellic acid. This difference in nodulation response is probably related to the already known fact that different genotypes of plants, presumably of varying endogenous gibberellin-levels, react quite differently to identical gibberellin applications.

A. W. Galston

Department of Botany, Yale University,
New Haven, Connecticut. Dec. 17.

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Quantitative Measurement of the Effect of Lysergic Acid Diethylamide on Mice and its Interactions with other Drugs

Although several species of animals (including spiders, fighting fish, pigeons and rats) have been used for the quantitative evaluation of the effect of hallucinogenic and psychotomimetic agents it is worth while to add to this list owing to the biochemical differences between species. The present favourite seems to be the rat[1]. This communication reports a test for the quantitative evaluation of the effect of psychotomimetic agents using mice chosen for their small size (useful if limited quantities of agent—for example, extracts from schizophrenic serum—are available) and ease of handling. A Latin square design was used employing four cages, each of 5 mice, and four modes of injection (saline, lysergic acid diethylamide, drug to be tested, and lysergic acid diethylamide and this drug together). The mice were injected subcutaneously and placed individually on the centre of a vertical pole at 1 min. intervals. The time (up to a maximum of 40 sec.) taken by the mice to reach lines drawn 1 in. from the top or bottom of the pole was then measured. Variability can be reduced by eliminating slow or erratic mice in preliminary tests. (The mice can also be trained to run down the pole under hunger drive. This procedure, however, introduces two new parameters—learning and hunger—which may be differentially affected by drugs.) Doses of lysergic acid diethylamide of 1 and 2 mgm./kgm. were used. The solutions were always freshly prepared and the effect tested of their interaction with adrenochrome, adrenolutin and the brom derivative of lysergic acid diethylamide. Fig. 1 shows the difference between the drug value and its matching saline value, with the latter corrected to a straight line at the level of the first saline value (maximum possible score = 200). All statistical work was done, however, on uncorrected results. As the results obtained were not normally distributed, all statistical evaluations were carried out using non-parametric methods (Wilcoxon's method for paired data).

It was found that lysergic acid diethylamide increases the time which the mice take to reach the end of the pole. This is maximum at 10–15 min. after injection and is still appreciable after 30 min. Bufotenin in doses up to 20 mgm./kgm. did not show any of this effect (nor any qualitative change). Adrenochrome in doses of 10 and 20 mgm./kgm. has no effect on mice demonstrable by this test or on the effect of lysergic acid diethylamide on mice. Adrenolutin inhibits the effect of lysergic acid diethylamide on mice but exerts no influence by itself in a dose of 20 mgm./kgm. (Fig. 1). This effect was confirmed in a further experiment using 40 trained hungry mice and 30 mgm./kgm. adrenolutin (P for the interaction of lysergic acid diethylamide and adrenolutin is between 0·02 and 0·05). The brom derivative of lysergic acid diethylamide in a dose of 1 mgm./kgm. produced a marked sedation of untrained mice and a delayed time for descending the pole. The same dose did not produce this effect in trained or hungry mice where, presumably, the sedative effect could be overcome by motivation or training. The morpholide derivative of lysergic acid diethylamide is less active but causes a late acceleration of the mice (at 30–60 min.: $P = 0·02$).

The purpose of this test is to evaluate the effect of lysergic acid diethylamide and other psychoto-

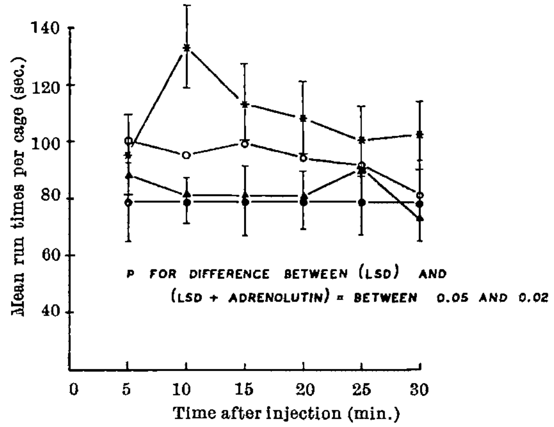

Fig. 1. Showing the effect of lysergic acid diethylamide (LSD), adrenolutin and their interaction. Cages *A–D*, each point representing 40 mice: ●, saline; ★, LSD (1 mgm. per kgm.); ▲, adrenolutin (20 mgm. per kgm.); ○, LSD + adrenolutin

mimetic agents quantitatively and to measure their interaction in mice. Inferences from these results to humans can only, of course, be made with caution. These experiments indicate that adrenochrome and adrenolutin (in the doses used) do not act on mice as lysergic acid diethylamide does and that they do not potentiate this action of lysergic acid diethylamide or vice versa (it has been claimed[2] that lysergic acid diethylamide in man potentiates the effect of adrenolutin). However, bufotenin, a known human hallucinogen, has no demonstrable effect either in mice even in large doses.

I am grateful to Dr. Harold E. Himwich and to Dr. Erminio Costa for their invaluable help and advice; to my technician, Mrs. Jennie Johnson, for her excellent work and to Drs. A. Hoffer, B. Melander of K.A.B.I., and S. Gimpel of Sandoz for generous gifts of adrenochrome, adrenolutin and lysergic acid and its brom derivative, respectively.

J. R. Smythies*
Thudichum Psychiatric Research Laboratory,
Galesburg State Research Hospital,
Galesburg, Illinois.

* Present address: Worcester Foundation, Shrewsbury, Mass.

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Antibody Formation by Isolated Spleen Cells transferred to Recipients in Absence of Homotransplantation Reaction

It is generally agreed that the internal environment in new-born animals is not favourable for antibody formation to occur, as has been postulated by Dixon[1,2]. It has, however, been demonstrated in our laboratory[3-5] that new-born animals are more suitable recipients for transferred cells producing antibodies—during the period when they are not capable of their own active antibody synthesis[6]—than X-irradiated adult animals. We suppose that the homotransplantation reaction is the main factor limiting antibody formation by cells transferred to young animals[7]. Simonsen[8] has shown that spleen cells of adult hens are tolerated if transferred to chicken embryos three days before hatching. We assumed, therefore, that by using the chicken embryo as recipient it will be possible to obtain fully developed formation of antibodies to bacterial antigens and also a positive primary response to a protein antigen. According to Dixon's assumption, this should, on the other hand, lead to a further decrease in the intensity of antibody formation in embryos.

Normal White Leghorns weighing 1·5–2 kgm. were used as donors of spleen cells, which were isolated as described in a previous report[4]. Spleen cells mixed with antigen *in vitro* were transferred either by intraperitoneal route to chickens 2 days after hatching or into the chorioallantoic vein of 18-day-old chicken embryos. 6×10^7 cells were transferred to chickens and 5×10^7 cells to embryos. The number of cells was determined by counting in a Bürker's chamber. A heat-inactivated suspension of *Brucella suis* (in a ratio of two bacterial cells to one spleen cell) and bovine serum albumin (1 mgm. per embryo or chicken) were used. Cells were transferred simultaneously with antigen; to controls, animal cells only or antigens only were given. Blood for determination of antibody titres was taken at different time-intervals according to the antigen used. This was usually 10, 14, 20 and 28 days after transfer in the case of bovine serum albumin and 5, 7, 9, 12, 16 and 24 days after transfer when using *Brucella suis*. Antibodies were determined by agglutination of the suspension of *Brucella suis* or tanned sheep erythrocytes sensitized by bovine serum albumin. 73 per cent of chickens hatched from the embryos to which spleen cells had previously been transferred died within 15 days after transfer with typical symptoms of the runt disease. The decrease of blood hæmoglobin in chickens before death was even lower than 10 per cent. Symptoms of the runt disease served at the same time as indicator of a successful cell transfer.

The experiments were performed as follows. In the first group, cells with the *Brucella* antigen were transferred to two-day-old chickens and 18-day-old embryos. The antibody formation occurred in all the 20 transfers to chickens, with a maximum titre 1 : 128 (M = 1 : 32). Out of 17 transfers to embryos there was a positive antibody response in all experimental chickens, with a maximum titre 1 : 130,000 (M = 1 : 4,096). The transfer of cells only (13 embryos, 7 chickens) or antigens only (12 embryos, 9 chickens) was always negative during the critical period, that is, up to the fifteenth day of life. This group of experiments is illustrated in Fig. 1. In the second group of experiments bovine serum albumin was used as antigen under the same experimental conditions. In none of the transfers to

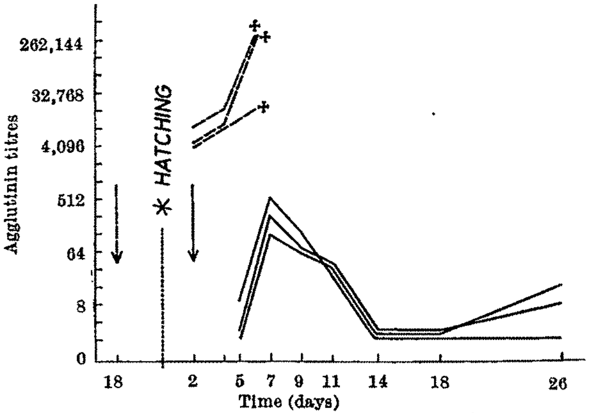

Fig. 1. Antibody formation following transfer of cells with *Brucella* antigen to embryos and chickens. Full line, transfer to 2-day-old chickens; interrupted line, transfer to 18-day-old embryos. A cross indicates that animals died with symptoms of the runt disease

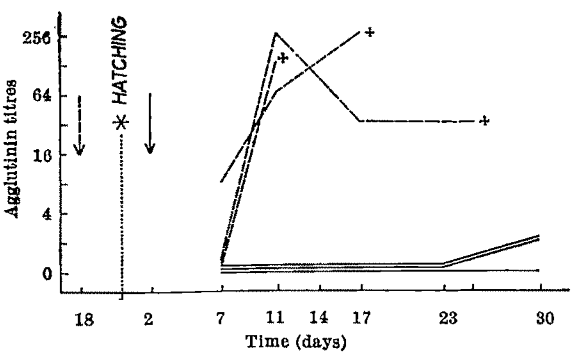

Fig. 2. Antibody formation following transfer of cells with protein antigen (bovine serum albumin) to embryos and chickens. Full line, transfer to 2-day-old chickens; interrupted line, transfer to 18-day-old embryos. A cross indicates that animals died with symptoms of the runt disease

chickens (26 transfers of cells with bovine serum albumin, 21 transfers of bovine serum albumin only and 18 transfers of cells only) was it possible to demonstrate any antibody formation. A positive response was, however, obtained in transfers to embryos during the critical period, that is, within 15 days; there were 21 positive responses out of 27 transfers performed, with a maximum titre 1 : 512 ($M = 1 : 64$). No antibody formation could be demonstrated in 18 control experiments in which cells only and in 27 control experiments in which bovine serum albumin only were transferred. This second group of experiments is illustrated in Fig. 2.

The results of our experiments primarily indicate that the immaturity of the recipient does not affect the response of the transferred cells, as has been postulated by Dixon and his co-workers, but that the limiting factor is the homotransplantation reaction. When the transplantation reaction is eliminated by using transfer to embryos, the transferred cells form antibodies in large titres. Using this experimental model in which the function of the transferred cells is not disturbed by the reaction of the recipient, we succeeded in obtaining antibody formation even to protein antigens, that is, in evoking a typical primary response.

Z. TRNKA
I. ŘÍHA

Division of Immunology,
Institute of Biology,
Czechoslovak Academy of Science,
Praha 6.

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Presence of Antigen—a Factor determining the Duration of Antibody Formation by Transferred Cells

In experiments on antibody formation by isolated spleen cells after transfer to new-born rabbits[1] and newly hatched chicks and embryos[2] it has been found that the ability to form antibodies is limited in time, this being due to the reaction of the recipient to the transferred cells[3]. If spleen cells only were transferred to new-born rabbits and then antigen administered at different time intervals, it was demonstrated that only during the first 4 days after cell injection did the administered antigen regularly evoke antibody formation. Injection of antigen on the fifth day gave positive results only occasionally, and administration of antigen after the seventh day did not result in production of antibodies by transferred cells.

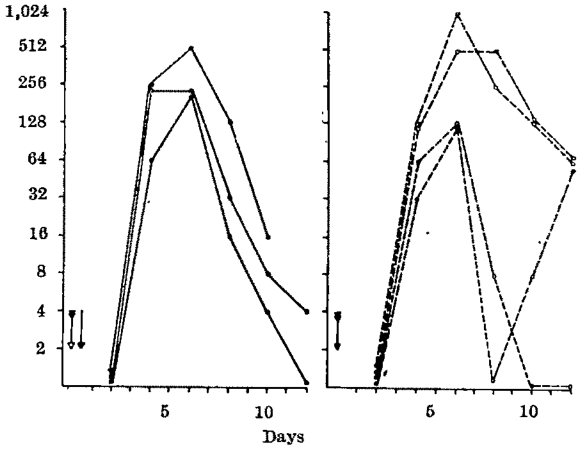

Fig. 1. Transfer of spleen cells intraperitoneally to one-day old ducklings. Left, 10⁸ spleen cells (in 1 ml.) from normal adult donor mixed with antigen *Brucella suis in vitro*; right, 50 × 10⁶ spleen cells (in 1 ml.) from adult donor immunized with three doses of antigen *B. suis*

In further experiments one-day-old ducklings were used as recipients in order to find out whether the reaction of the recipient to the transferred cells is the only factor determining the period during which they are capable of producing antibodies. It is known[4] that at that period of life these animals are tolerant to transferred cells. Ducklings injected with bacterial antigen (*Brucella suis*) commence the formation of antibodies after the twelfth to fifteenth day of life.

Spleen cells from immunized adult duck or spleen cells from non-immunized donor mixed with antigen *in vitro* were transferred to one-day-old ducklings. In both cases (Fig. 1) the injected cells produced antibodies during a short period after transfer. Since the cells were injected into animals in which the decline in antibody formation cannot be ascribed to

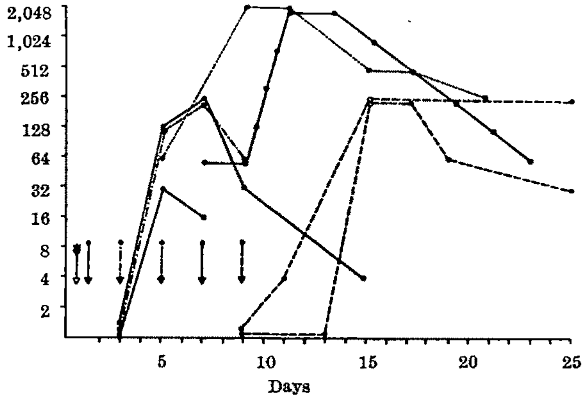

Fig. 2. Transfer of adult spleen cells only to one-day-old ducklings. Individual groups were injected with antigen *B. suis* immediately or 2, 4, 6 or 8 days after administration of cells

the homotransplantation reaction, we tried to find another explanation. It was assumed that the transferred cells differentiate in the recipient's body and that antibody production is determined by the life-span of those differentiated cells incapable of further proliferation ; another possible explanation was that the antigen was used up during the formation of antibodies and that the transferred cells, though capable of antibody response, do not produce antibodies because of the absence of antigen.

After the transfer of cells, antigen was injected into individual groups of ducklings at different time-intervals ; one of the results is given in Fig. 2. The formation of antibodies evoked by antigen administration (at the period in which active antibody response to antigen is not yet developed in ducklings) indicates the presence of transferred cells capable of reacting to antigen even at that time when the spleen cells from immunized donor or cells mixed with antigen *in vitro* and transferred to ducklings cease to produce antibodies (Fig. 1). The decrease in antibody formation by transferred cells may be explained by the absence of antigen.

These findings show that transfers to non-reactive recipients may be used for determining the importance of the presence of antigen for antibody formation.

Further details will be published elsewhere[5].

J. Šterzl

Division of Immunology,
Institute of Biology,
Czechoslovak Academy of Science,
Praha 6.

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Antiviral Activity of Lysozyme

The biological significance of lysozyme is not yet fully established. Its properties suggest that it has a role in immunism against bacterial infections. Lysozyme also seems to show antiviral activity. Previous observations support this possibility.

Macfarlane Burnet[1] observed that nasal mucus inactivates poliomyelitis virus of any type *in vitro* ; on the other hand, however, pure lysozyme did not. Caselli and Schumacher[2] demonstrated antagonism between lysozyme and electronegative viruses. Orzalesi[3] obtained very satisfactory results in the treatment of herpetic keratitis with lysozyme and observed the inactivation of herpetic virus by lysozyme *in vitro*.

Pursuing this line of research on the relationship between lysozyme and viruses, some interesting results have been obtained in our laboratories. *In vitro*, we observed that lysozyme precipitated bacteriophage viruses and *in vivo*, in guinea pigs experimentally infected with aphthosis virus, we obtained good results with the administration of lysozyme in 80 per cent of the animals.

Callerio observed a constant reduction of serum lysozyme in poliomyelitis patients, but some therapeutic trials with this enzyme were confusing. A communication from A. D. Ronchese of Nice, stating that he has obtained recovery in four cases of herpes zoster by oral treatment with lysozyme, induced us to extend our clinical observations[4].

Many Italian dermatologists have tried the administration of lysozyme by parenteral route in several virus diseases.

Lysozyme, in adequate dosage, has been shown to be effective in the treatment of viral infections such as herpes simplex, herpes zoster, warts, condylomata acuminata, aphthosis and vaccinia. These results need further confirmation, however, so that the antiviral spectrum of lysozyme as well as its real value in the therapy of viral diseases may be definitely established.

Rodolfo Ferrari
Carlo Callerio
Giuseppe Podio

Istituto di Ricerche Terapeutiche
'Alexander Fleming',
Via 8 Bialla, Milan.
Dec. 12.

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BACTERIOLOGY

Decomposition of Anionic Surface-Active Agents by Soil Bacteria

In a review of water pollution problems created by the persistence of anionic surface-active compounds in sewage and sewage effluents, Southgate[1] has pointed out that sodium alkyl sulphates are more susceptible to biological degradation than the alkyl benzene sulphonates which are active constituents of some domestic detergents. This resistance of the alkyl benzene sulphonates of commerce to biological oxidation has been attributed to the branched carbon atom chains of their alkyl groups. On the other hand, the alkyl sulphates in common use have, fortuitously, alkyl groups with straighter carbon chains more readily oxidized by micro-organisms[2]. Although some bacteria attacking anionic compounds have been reported[3], there is very little published information on bacteria responsible for breaking down even the more easily decomposable compounds.

This communication records the isolation of a bacterium able to use both primary and secondary alkyl sulphates as carbon sources. This organism developed from a sample of allotment soil which had been incubated at 25° C. for two weeks with water containing a trace of 'Teepol 530', a secondary alkyl sulphate. After further cultivation in a buffered mineral salt solution ($(NH_4)_2SO_4$, 0·5 gm. ; K_2HPO_4, 6·5 gm. ; KH_2PO_4, 3·5 gm. ; $CaCl_2$, 0·05 gm. ; $MgSO_4.7H_2O$, 0·05 gm. ; NaCl, 1·0 gm. ; distilled water, 1 litre ; *p*H 7·0) with 0·1 ml. 'Teepol' per litre, the organism was isolated from plates of the same medium solidified with 1·5 per cent agar.

Cells of this isolate are aerobic, Gram-negative rods, $0·6–0·7\mu \times 0·6–2·2\mu$, with polar flagellation. Only in very young cultures are all the cells vigorously motile. On nutrient agar prepared from fresh ox heart extract and peptone, a trace of greenish fluorescent pigment appeared in the medium ; but little or no such pigment formed in media made from commercial meat or yeast extracts. Acid but no gas was formed from glucose, fructose, mannose, galactose, xylose, arabinose, sucrose, maltose, lactose, glycerol and mannitol. Starch, cellulose, salicin and *Ricinus* seed oil were not attacked. In the test of Shewan *et al.*[4], growth was inhibited by streptomycin, chloramphenicol and terramycin but not by penicillin or the vibriostatic agent 0/129. For these reasons the organism has been referred to the genus *Pseudomonas*; but the species has not yet been identified or named. It does not correspond well with any previously described soil or freshwater species.

The effect of the growth of this organism on surface tension in mineral salt solution containing different concentrations of 'Teepol 530' has been examined (Table 1). Surface tension measurements were made with a du Noüy tensiometer at 20° C.

Table 1. CHANGES IN SURFACE TENSION OF MEDIA CONTAINING DIFFERENT CONCENTRATIONS OF 'TEEPOL 530' DURING TWO DVYS OF INCUBATION

Conc. 'Teepol' ml./l. medium	Surface tension (dynes/cm.)					Increase (per cent)
	Initial		After 2 days		Increase	
	Duplicate samples	Mean	Duplicate samples	Mean		
0·1	36·2 35·3	35·8	68·3 68·1	68·2	32·4	90·5
0·2	35·7 35·2	35·5	66·7 67·3	67·0	31·5	88·7
0·5	32·9 32·4	32·7	53·4 53·2	53·3	20·6	63·0
1·0	31·5 31·4	31·5	42·8 41·6	42·2	10·7	34·0
2·0	31·3 31·3	31·3	33·2 33·0	33·1	1·8	5·8

After two days cultures originally containing 0·5 ml./l. 'Teepol' or less had almost no tendency to foam on shaking. Foam stability was also greatly decreased in cultures with higher concentrations of 'Teepol' even though increases in surface tension had been only slight during the period of test. In a second experiment in which 500 ml. portions of the same basal medium containing 2 ml. 'Teepol' per litre were incubated for 16 days, foam was also very unstable after 3 days but did not become noticeably more unstable thereafter. Though growth, as judged by measurements of turbidity, ceased between the fourth and sixth days, surface tension rose steadily from 31·1 dynes/cm. at the start of the experiment to a final, but still low, value of 47·0 dynes/cm. on the sixteenth day. The bacterium could grow well in media containing, as sole carbon sources, primary sodium alkyl sulphates with alkyl groups of 10–18 carbon atoms. Also utilized were all the five 'Empilan' alkylolamide detergent additives which were tested: these were Types *AL*, *CM*, *LDE*, *LP*2 and 303 (Marchon Products, Ltd.). However, tetrapropylene benzene sulphonate, an active constituent of some commercial detergents, was not attacked. Indeed, though many soil micro-organisms were observed to tolerate the presence of this persistent compound, none capable of utilizing it could be isolated.

F. A. SKINNER

Soil Microbiology Department,
Rothamsted Experimental Station,
Harpenden, Herts.

Dec. 9.

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Malachite Green - reducing Enzyme in *Mycobacteria*

In experiments with the lipids of different *Mycobacteria* we found that the acetone solution of lipids becomes green in colour as a result of certain oxidizing agents. A more precise examination revealed that such a change in colour occurred in the lipid solutions of only those bacteria which were grown in media containing malachite green.

Four saprophytic (*M. butyricum*, *M. friburgensis*, *M. rabinowitsch*, *M. smegmatis*) and two parasitic (*H*37*Rv.*, Ravenel) strains were grown in normal Sauton culture medium and in Sauton culture medium containing malachite green (10 μgm./ml.) respectively.

After incubation for six days the saprophytic cultures were filtered by means of paper filters, washed five times with distilled water, and dried at 37° C. over calcium chloride. 250 mgm. dry weight of the bacteria was suspended in 2·5 ml. acetone and left at room temperature for 10 min. Then 250 mgm. of lead dioxide was added, and the tubes were shaken, and centrifuged. The supernatant contained lipids or, in the case of a medium containing malachite green, it contained this dye. The parasitic strains were incubated for 50 days, sterilized in the autoclave, and then treated in the same manner as the saprophytes. In order to identify the dye and to measure its quantity, the absorption curves of the solutions were determined with the use of a Beckman spectrophotometer at 340–700 mμ wave-lengths.

It was found that the maximal absorption values for the solutions of the bacteria grown in a medium containing malachite green were at 420 and 630 mμ. In contrast, the solutions of the bacteria grown in normal Sauton medium showed no absorption at the wave-lengths studied. The maximal absorption values for the acetone solutions (2 μgm. per ml.) of the malachite green oxalate used were found to be at 430 and 630 mμ. The relative intensity of the absorptional maximal values was 630 > 430 or in the case of bacterial lipid solutions 630 > 420.

On the basis of the results of spectrophotometric examination it seems likely that malachite green is reduced by the growing bacteria, and the leuco-compound remains absorbed in the bacterial bodies. By means of lipolysing agents, it can be extracted together with the bacterial lipids, and then it becomes again a coloured compound after oxidation. The amount of the dye reduced is great, as shown by the fact that ten times as much malachite green (20 μgm./ml.) as the quantity used in normal media (for example, Sula medium) can be reduced by growing mycobacterial strains.

In order to establish the *p*H optimal for reduction, acetone-dry preparations made according to Edson's and Hunter's method[1], saprophytic *Mycobacteria* grown in Sauton medium for 5 days, were used. Such preparations can be stored for indefinite periods in refrigerators without loss of potency.

In order to measure the amount of the dye reduced at various *p*H-levels under the same periods of time, 10-mgm. acetone-dry preparations were placed in dry Wassermann tubes. After the addition of 1 ml. of universal buffer solution and 10 μgm. of malachite green (dissolved in 0·2 ml. water) the tubes were incubated in a water-bath of 37° C. for 30 min. Then, the tubes containing the suspensions were shaken in the presence of 2 ml. of acetoacetic ester for 5 min. and centrifuged. The upper aqueous layer was

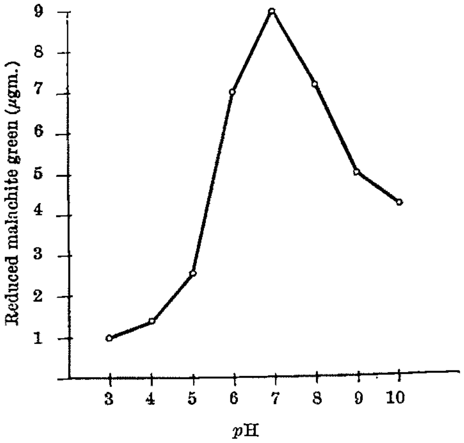

Fig. 1. Effect of *p*H on the reduction of malachite green by acetone-dry powder of *M. friburgensis*. Incubation, 30 min. at 37° C., in universal buffer solution

removed. To the acetoacetic ester malachite green solution 100 mgm. of anhydrous magnesium sulphate was added, the tubes were shaken, centrifuged, and the pure solution obtained was examined with a spectrophotometer at 630 mμ to determine the amount of malachite green.

The *p*H optimal for reduction was found to be 7·0 (Fig. 1).

Using *p*H 7·0 buffer solution the preparations were entirely inactivated by incubation at 60° C. for 30 min.

In addition, inactivation of the preparations could be obtained by *p*-chlormercuric benzoic acid, monoiodoacetic acid and hydrogen peroxide. Cystein or glutathione was found to reactivate the inactivated preparations.

The enzyme responsible for the reaction could not be extracted from the bacteria by the usual methods. It is suggested, therefore, that this enzyme is not identical with the reported reducing enzymes of the *Mycobacteria*[2-5].

Further observations will be reported in due course.

Iván Tárnok
Pál Czanik

Diagnostic Laboratory,
'Korányi' National Institute for Tuberculosis,
Budapest 124.

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Selection of Bacterial Mutants of Increased Sensitivity to 'Aminopterin'

Some understanding of the cellular responses which modify the effectiveness of growth-inhibitors can be gained by the study of closely related populations of microbial or mammalian cells differing in degree of sensitivity to a drug. Microbial cell lines resistant to antibiotics and antimetabolites can be developed readily by the selection of cells capable of surviving in the presence of increasing concentrations of such drugs[1]. Similar selection of drug-resistant neoplastic cells has been accomplished both *in vivo*[2] and *in vitro*[3]. Occasionally the development of resistance to one drug is accompanied by changes which confer an increased sensitivity to a different agent, a finding applicable to both microbial[4] and neoplastic cells[2,5]. The physiological mechanisms and metabolic systems associated with any increased effectiveness of drugs are of vital concern, but have received little attention because of the technical difficulty of directing the selection towards an increased, rather than decreased, responsiveness to a drug if that drug is used as the selecting agent. This communication concerns the reproducible selection in the absence of the drug of bacterial mutants of increased sensitivity to a folic acid antagonist ('Aminopterin').

Pediococcus cerevisiae, strain 8081, has been widely used for the assay of reduced derivatives of pteroylglutamic acid (folic acid) such as 5-formyl-tetrahydropteroylglutamic acid, which have folinic acid activity[6]. This organism can grow, however, in the absence of folinic acid if very high concentrations of pteroylglutamic acid are provided in the medium[7]. Pteroylglutamic acid was used as a selecting agent for strains which could grow well in media supplying progressively smaller amounts of this form of the vitamin. Over the course of eleven transfers, the concentration of pteroylglutamic acid necessary for growth was reduced from 2,000 mμgm. to 10 mμgm. per ml. of medium. The response of the selected strain (8081/*S*) to 5-formyl-tetrahydro-pteroylglutamic acid was identical to that of the parent organism (Table 1). Thus, it was possible to compare the sensitivity of these strains to 'Aminopterin' in the absence of the selecting agent by using a medium containing 5-formyl-tetrahydro-pteroylglutamic acid. The selection of strains capable of growing in medium containing 10 mμgm. of pteroylglutamic acid per ml. was repeated twice. In each case these cell lines were found to be 60–100 times more sensitive to 'Aminopterin' than the parent strain (Table 1). The characteristics of increased sensitivity to 'Aminopterin' and ability to grow promptly at low concentrations of pteroyl-

Table 1. Comparison of the Response of *Pediococcus cerevisiae* 8081 and a Selected Mutant (8081/*S*) to Folic Acid, Folinic Acid and 'Aminopterin'

Compounds tested		*Pediococcus cerevisiae* Parent strain 8081	Mutant strain 8081/*S*
Liquid medium*		mμgm. per ml. of liquid medium	
Pteroylglutamic acid (folic acid)—amount required for half-maximal growth		>1,000	3·0
5-Formyl-tetrahydro-pteroylglutamic acid (folinic acid)—amount required for half-maximal growth		0·4	0·4
4-Amino-pteroylglutamic acid ('Aminopterin')—amount required for inhibition of growth by 50 per cent†		160	2·5
Solid medium‡	mμgm. per pad	Diameter of zone (mm.)	
Pteroylglutamic acid (zone of growth)	10	No zone	16
	100	,,	24
	1,000	,,	31
4-Amino-pteroylglutamic acid (zone of inhibition)†	10	,,	19
	100	,,	26
	1,000	17	30

* The compounds were added to a medium used for the microbial assay of folinic acid activity (refs. 6 and 7). The concentration required for 50 per cent growth was determined from a graph of the complete curves for growth and inhibition.

† The inhibition of growth by 'Aminopterin' was measured in liquid and solid medium which contained 1·0 mμgm. per ml. of the active isomer of 5-formyl-tetrahydro-pteroylglutamic acid.

‡ The same medium with the addition of 1 per cent agar was seeded with each organism and poured into flat 'Pyrex' dishes. Solutions of the compounds were pipetted on to filter paper disks of ½ in. diameter which were placed on the surface of the solid medium. Each figure represents the average diameter of two zones, each measured along two 90° axes.

glutamic acid were retained after fifteen passages in the absence of the selecting agent.

In this case, in which the metabolite, pteroylglutamic acid, exerted a selective pressure in the direction of its more effective utilization, the selection was consistently accompanied by an increased sensitivity to a corresponding antimetabolite, 4-amino-pteroylglutamic acid. The ability to use a metabolite as a selecting agent apparently requires that the organism should have the potentiality of increasing its efficiency for the utilization of the metabolite. In any instance in which such a selection can be accomplished, this approach appears to be useful for the study of an altered response to corresponding antimetabolites. The requirement of cultures of leukæmic cells for 5,000-fold higher concentrations of folic acid than folinic acid[8] indicates that similar manipulation of the sensitivity of such neoplastic cells may be feasible. An equivalent increase in the sensitivity of strain 8081/*S* has been observed with respect to both 4-amino-pteroylglutamic acid and 4-amino-10-methylpteroylglutamic acid ('Methotrexate'); related compounds can be compared with respect to cross-sensitivity. Also, it will be of interest to study any characteristics which can be associated with the increased sensitivity of strain 8081/*S* to 'Aminopterin' in relation to the development of resistance by cells of this strain selected by this drug.

The mutant of *Pediococcus cerevisiae* (strain 8081/*S*) selected by pteroylglutamic acid now resembles *S. faecalis* and *L. casei* with respect to their characteristic growth requirement for either folic acid or folinic acid and their high degree of sensitivity to 'Aminopterin' and 'Methotrexate'. The nutritional selective pressure used in these studies may be a counterpart of the natural selection which occurred at some time during the evolutionary development of organisms such as *S. faecalis* and *L. casei*.

This investigation was supported in part by a research grant (*CY* 2906) from the National Cancer Institute of the U.S. Public Health Service. The capable assistance of Mr. Robert J. Leonard is gratefully acknowledged.

CHARLES A. NICHOL
Department of Experimental Therapeutics,
Roswell Park Memorial Institute,
Buffalo 3, New York. Dec. 11.

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AGRICULTURAL SCIENCE

Varietal Resistance to Spray Damage in Barley

IN experiments designed to control insect pests in the cereal nursery at the Welsh Plant Breeding Station it was noticed that there was considerable damage on barley plants after spraying with a proprietary insecticide containing DDT, which had been applied according to the manufacturers' instructions for field spraying. Certain plants suffered severe chlorosis; the sprayed leaves turned yellow and failed to recover, while succeeding leaves were green and appeared to be unharmed although productivity was severely reduced. Spraying at the early seedling stage and under unfavourable environmental conditions caused wilting and even death of the plant.

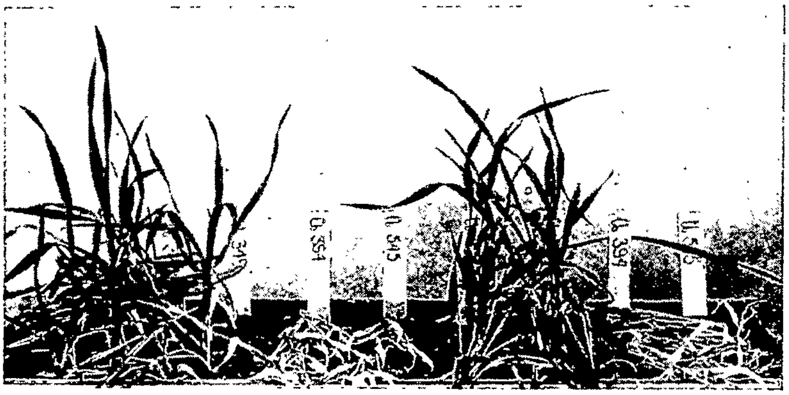

Fig. 1. Typical reaction of four barley varieties to spray damage. *R*, resistant; *S*, susceptible

Further investigation in both greenhouse and field nursery showed that the damage was confined to certain varieties. Fig. 1 shows the clear-cut reactions of typical resistant and susceptible varieties under greenhouse conditions. Twenty-six commercial varieties of barley are classified in Table 1 according to a distinct reaction of resistance or susceptibility to spray damage.

Table 1. REACTION OF SOME BARLEY VARIETIES TO SPRAY DAMAGE

Resistant	Resistant	Susceptible	Susceptible
Balder	Maythorpe	*Atlas	Praecox
Carlsberg II	Prefect	Domen	Piroline
Earl	Proctor	Freja	Primus
*Goldberg	Provost	Frisia	Rika
*Gull	Spratt Archer	*Haidd Hen Enlli	Vinesco
Ingrid	Ymer	*Hen Gymro	Wisa
Kenia		Herta	

* 'Land' variety or selection

Preliminary evidence that this reaction is genetically controlled was obtained by studying the pedigree of the above varieties. For example, it can be seen from Table 1 that Provost (resistant) was derived from a cross between Kenia and Spratt Archer, both of which, it will be noted, are resistant, while Prefect is a resistant segregate from the susceptible form Praecox and the resistant Spratt Archer. Confirmatory evidence of the genetic mechanism involved was obtained from the reaction of F_1 and F_2 plants from crosses of resistant and susceptible parent plants. Progeny from resistant × resistant crosses were all resistant to spray damage, while susceptible × susceptible crosses gave only susceptible progenies.

Table 2. REACTION OF F_1 PLANTS AND F_2 SEGREGATES FROM RESISTANT × SUSCEPTIBLE CROSSES

Parents	Generation	Expected or observed	No. of plants	
			Resistant	Susceptible
Resistant × Susceptible	F_1	Observed	—	72
	F_2	Observed Expected (3 : 1 ratio)	83 71·5	203 214·5

$\chi^2 = 2{\cdot}25$. $P = 0{\cdot}50$–$0{\cdot}10$.

Inheritance studies on resistant × susceptible crosses gave the segregation in Table 2.

All the available evidence, therefore, strongly indicates that varietal differences are controlled by a single major gene with susceptibility dominant to resistance.

Reference to Table 1 emphasizes that the alleles are randomly distributed among the commercial varieties of barley; thus there is no suggestion that this gene has had any selective influence in previous plant-breeding programmes. Furthermore, studies to date have not revealed any gross morphological features associated with this reaction. It is interesting to note the reaction of the five 'land' varieties and their derivatives; for example, Gull, the 'land' variety from Sweden, is resistant, while recently bred varieties from the same country, namely, Herta and Rika, are susceptible. Atlas, a selection from Coast which is believed to have been introduced into North America by the Spanish settlers, and Hen Gymro from Wales, are both susceptible. Thus there does not seem to have been any advantage or disadvantage associated with this gene during the evolution of the cultivated barleys. Since the use of insecticides on agricultural crops is of recent origin, it follows that this factor, which does not appear to have any other expression, has not hitherto been selected by plant breeders.

A knowledge of varietal reaction of this nature is important to research workers developing new insecticides as well as plant breeders. It will be a simple matter from the plant breeding point of view to avoid developing new varieties of barley which are susceptible to this damage, on account of the fairly large number of well-adapted resistant types already available. Further work is in progress to determine the nature of the chemical constituent responsible for the damage and the full genetic and physiological action involved.

Fuller details of this investigation will be published elsewhere.

J. DESMOND HAYES

Welsh Plant Breeding Station,
University College of Wales,
Aberystwyth. Dec. 5.

Rumination in Sheep caused by Injection of Adrenaline

THE injection of adrenaline into sheep anæsthetized with chloralose causes a rapid secretion of parotid saliva[1]. This is a reflex effect and appears to be due largely to stimulation of receptors in the forestomach. Parotid secretion is also increased by mechanical stimulation of the forestomach and in conscious sheep this stimulation may cause rumination[2]. Thus it seemed of interest to find whether adrenaline would cause the conscious sheep to ruminate, and observations on this subject are summarized here.

Six sheep trained for the experiments were each fitted with a rumen cannula and a cannula in one parotid duct. Contractions of the reticulum were recorded with a water manometer connected to a balloon placed in the organ and the flow of parotid saliva was recorded with a Throp drop counter. Adrenaline ('Adrenalin'; Parke, Davis) was injected during 5 sec. through a catheter inserted into a jugular vein.

A period of rumination followed adrenaline injection in all the sheep. An example is shown in Fig. 1, in which the onset of rumination is signalled by a triphasic contraction of the reticulum of lower amplitude than previous contractions and is accompanied by an increase in parotid secretion.

The threshold dose of adrenaline was 0·2–0·7 μgm./kgm. body-weight and there was a delay of 40–155 sec. between the start of the injection and the first regurgitation. Rumination was preceded by a number of changes, including alert movements of the head, sneezing, belching, urination or an increase in parotid secretion. Removal of the rumen contents and of the reticulum balloon made little or no difference to the threshold dose. In such sheep 'rumination' consisted of triphasic reticulum contractions and regurgitation of fluid. Larger doses of adrenaline (2–20 μgm./kgm.) caused rumination in most trials, although the initial triphasic reticulum contractions were often depressed. The latency of the response varied from 24 to 137 sec. Slow injection of adrenaline in doses of 1–20 μgm./kgm. during 2 min. failed to cause rumination. Noradrenaline ('Levophed'; Bayer) caused rumination in 3 of the 4 sheep tested at threshold doses of 1·5, 2·5 and 5·0 μgm. noradrenaline base/kgm. Injections of saline alone had no effect.

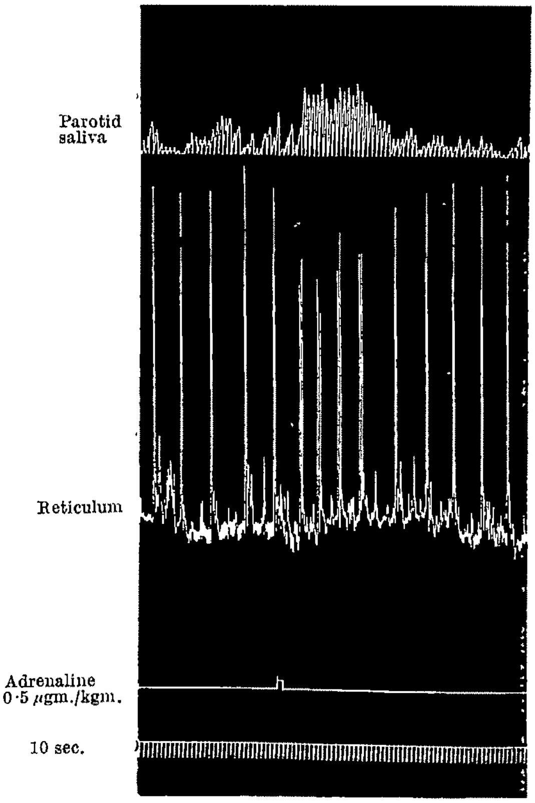

Fig. 1. Rumination caused by intravenous injection of adrenaline. Records from above downwards: parotid secretion (counter returned to base-line at 10-sec. intervals), reticulum contractions, signal, 10-sec. time marker

It is possible that adrenaline causes rumination by the same reflex mechanism that is concerned in the stimulation of parotid secretion in anæsthetized sheep. It is unlikely that the adrenaline acts on forestomach mechanoreceptors indirectly by causing muscular contraction, for no abnormal contraction was recorded from the reticulum and its action on the stomach of conscious sheep is known to be inhibitory[3]. The threshold dose of adrenaline, 0·2–0·7 μgm./kgm., corresponds to mean plasma adrenaline concentrations of 4–14 μgm./l., assuming 50 ml. plasma/kgm. body-weight. Although these concentrations are similar to those of 2·44–12·6 μgm./l. found by Weil-Malherbe and Bone[4] for bovine plasma, the blood analysed by these authors was collected at slaughter when adrenaline-levels might well be elevated abnormally. Moreover, to cause rumination the adrenaline had to be injected rapidly, so that the actual plasma concentration will transiently have exceeded the mean plasma concentration. It must be emphasized, therefore, that the present observations do not indicate that adrenaline release plays a part in the initiation of rumination in the normal animal. On the other hand, Loewenstein[5] has shown that both the application of adrenaline or noradrenaline to frog skin and stimulation of the sympathetic innervation cause activity in cutaneous touch receptors, and suggested that sensitization of such receptors through the sympathetic nervous system might normally occur in intact animals. The receptors of the sheep's forestomach may also be sensitized in this way.

R. N. B. KAY

Rowett Research Institute,
Bucksburn,
Aberdeenshire. Dec. 6.

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Inducing Chlorophyll Formation in Albino Citrus Seedlings

ALBINO seedlings, that is, seedlings lacking chlorophyll, are observed in varying degrees in citrus seed beds according to variety. In sweet lime 30 per cent or more of the young seedlings may be albino. This lack of chlorophyll is attributed by some botanists to infection with an unknown disease. Treating citrus seeds before planting with mercuric disinfectants such as 'Ceresan'[1] and 'Agrosan'[2] resulted in the production of seedlings which with the former were nearly all and the latter all green. In this study albino seedlings were grafted on to green seedlings to see whether chlorophyll formation would be blocked in the latter as a result of possible transmission of the disease which is suspected to cause albinism or whether chlorophyll formation could be induced in albino seedlings.

Sweet lime seeds were planted in a mixture of 1 part sand to 3 parts loam in an incubator at 28–30° C. and 80–90 per cent humidity. Because the sweet lime is polyembryonic, more than one seedling were produced per seed. In many instances both albino and green seedlings were produced from the same seed, and thus were very close to each other, making grafting in these young seedlings possible. Grafting was done by the approach method in which a small slice of stem of both the albino and the green seedlings were cut and the cut surfaces brought together and tied until they united. The cuts were made as high as possible to leave a few buds on the stem of each seedling. Grafting was done as soon as the plants were about 5 cm. high. Too long a delay must be avoided, for the albino seedlings usually die after using up the food reserve in the embryos from which they develop.

Out of 30 grafts 11 succeeded. The tops of the albino seedlings above the grafting union died. None of the green seedlings in these successful grafts showed any chlorophyll irregularities as a result of grafting an albino seedling (which is supposedly diseased) on it.

A year later, leaves of the originally green seedlings were still green and the stems of such seedlings at the grafting union-level was about 1 cm. in diameter. The stems of the albino seedlings reached about the same diameter but no shoots grew on them, although they had a few buds on each. These buds were forced to grow by ringing the stems of the originally green seedlings immediately above the grafting union. All shoots produced in this way had only green leaves and seemed normal. These shoots remained green after separation of the two seedlings from each other.

These findings indicate that the causal factor of albinism was not transmitted across the grafting union, or if transmitted was unable to induce albinism in the originally green seedlings. The results also show that the effect of this causal factor is temporary and limited to the early stages of seedling growth. Cutting off the top of the originally green seedlings to the grafting union or separation of the originally albino from the originally green seedling (top and root) did not cause any disturbance in chlorophyll formation in the green shoots obtained from originally albino seedlings. This result seems to contradict the view that albinism is due to recessive genes, as was claimed for the Szinkom mandarin[3].

FAISAL A. MINESSY

College of Agriculture,
University of Alexandria,
Egypt. Dec. 8.

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Antigenic Stimulus of Exsheathing Fluid in Self-Cure of Sheep infested with *Haemonchus contortus*

IT has been reported that the second ecdysis of *Ascaris lumbricoides* is probably important in the stimulation of protective immunity in guinea pigs[1–2]. Up to 4 days after the administration of ova, developing larvæ appear to be of little importance in stimulating immunity and are themselves unaffected by immune processes. Using the Forssman antibody as a natural marker, it was demonstrated that a large release of antibody does not occur until 4–5 days after the administration of ova[3]. This period coincides with the second ecdysis, and it was suggested that this process is important in stimulating immunity by the liberation of antigens.

Two stages are involved in the second ecdysis of nematode larvæ in sheep[4]. Larvæ are activated by a dialysable factor or factors in the alimentary tract and then secrete exsheathing fluid from a region near the base of the œsophagus. Exsheathing fluid acts on a circumscribed region of the cuticle which eventually fractures and enables the larva to escape. Exsheathing fluid was collected as a dilute solution[5] which was found to contain other antigenic substances also released by the larvæ at the time of the second ecdysis.

The self-cure reaction is produced in hypersensitive infested sheep by the intake of infective larvæ. The reaction is accompanied by a rise in circulating antibodies and a transitory rise in blood histamine[6].

The serological reaction which occurs at the time of self-cure has now been examined by the Ouchterlony agar-diffusion precipitin technique. It was found that four lines developed when heated *Haemonchus contortus* antigen[7] was tested with a serum obtained when self-cure took place after the administration of *H. contortus* infective larvæ to an infested sheep. The antigenic components responsible for the main reactions were identified by the cross-reactions which occurred between the serum, the heated antigen, exsheathing fluid solution from *H. contortus* infective larvæ and metabolic products. The metabolic products were collected by harvesting a saline solution in which exsheathed *H. contortus* infective larvæ had been kept with added antibiotics for 24 hr. at room temperature. The line which appeared closest to the antigen well was produced by tissue antigens, the second line also by tissue antigens together with a component due to exsheathing fluid solution, the third line mainly by exsheathing fluid solution but partly by metabolic products, and the fourth line, closest to the serum well, was produced primarily by metabolic products. It is not surprising that there was some overlapping between these lines, because exsheathing fluid solution was found to contain a number of antigenic substances, some of which are also present in metabolic products.

The agar-diffusion precipitin reactions developed with serum collected within a week of the administration of larvæ, and the lines produced by metabolic products and particularly by exsheathing fluid solution were the most pronounced. By slaughtering infested sheep at intervals after the administration of infective larvæ it was found that, at the time of the self-cure reaction, when much of the existing adult *H. contortus* infestation was located in the small intestine and was in a state of disintegration, fourth-stage larvæ of varied size as well as third-stage larvæ were present in the abomasum. It seems probable, therefore, that the self-cure reaction is initiated by an antigenic stimulus arising from the third ecdysis. Although there is as yet no evidence that the third ecdysis produces exsheathing fluid, the serological evidence indicated that similar antigens were released as in the second ecdysis.

E. J. L. Soulsby
R. I. Sommerville
D. F. Stewart

McMaster Animal Health Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Parramatta Road,
Glebe, New South Wales. Dec. 2.

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BIOLOGY

Occurrence of *Pyrosoma* on the Sea-Floor 160 Metres Deep

Pyrosoma species are commonly encountered as surface or midwater planktonic organisms. Among photographs taken of the sea-floor of Cook Strait, New Zealand, two exposures show what are undoubtedly tunicates, almost certainly *Pyrosoma atlanticum atlanticum* Peron, resting on or swimming just above the bottom at a depth of 160–170 m.

The depth is in itself not unusual—Thompson[1] reports finding this species off Australia in greatest numbers between 250 and 500 m.—but we are not aware of previous records of *Pyrosoma* so close to the bottom. It may be that our records indicate no more than a normal range of depth distribution. On the other hand, since they were made at 1022 and 1505 hr. they may indicate a daytime preference for deeper water; Thompson does not indicate the times at which his observations were made. It is possible that the animals are actively seeking the bottom to avoid other unfavourable surface conditions.

The shadows cast by a camera flash (New Zealand Oceanographic Institute Station *C*.122, 18.5.58; 162 m.; lat. 41° 19′ 04″ S.; long. 174° 32′ 36″ E.) show that the *Pyrosoma* are within inches of the bottom, and some are certainly resting on it. They are firm and regular in shape, indicating that they are not dead and decomposing. Shadows and blurred shapes in another photograph (New Zealand Oceanographic Institute Station, *C*.119, 17.5.58, depth 169 m.; lat. 41° 18′ 45″ S.; long. 174° 32′ 30″ E.) indicate specimens actively swimming just above the sea-floor.

At this time of the year (May 1958), *Pyrosoma* were extremely common in the Cook Strait region. Mr. N. M. Ridgway, of this Institute, noted that colonies up to 15 in. long were frequently seen swimming past the ship at night during May 15–19, and were occasionally entangled in the wires used for current measurements. On May 16, Mr. F. C. Abernethy, engineer of the trawler *Thomas Currel*, recorded large numbers off Cape Campbell at a position (lat. 41° 54′ 36″ S.; long. 174° 11′ 55″ E.) approximately 40 miles from Stations *C*.119 and *C*.122, and noted the surface temperature as 54° F. (12·2° C.).

Prof. H. B. Fell, of Victoria University of Wellington, has brought to our notice a record of another observation by Mr. Abernethy, some time shortly before October 20, 1952, when the sea-floor off Cape Campbell was covered with dead *Pyrosoma* at a depth of 100 m. The animals were in an advanced state of decomposition, and were present in quantity in the trawl. Mr. Abernethy informs us that fishermen in this area frequently take dead *Pyrosoma* in this condition at certain times of the year.

The nature of the bottom in the photographs taken is an interesting commentary on conditions apparently suitable for *Pyrosoma*. The bottom is of clean-swept cobbles, completely lacking in the usual fauna found in nearby rocky bottom areas where there is a certain amount of muddy matrix, and indicates a fairly strong current. Measurements of the bottom current were made at Station *C*.122 by Mr. A. E. Gilmour of this Institute, and were found to vary between $\frac{1}{2}$ and $\frac{3}{4}$ knot at 10 in. above the bottom. Surface currents were 1–4 knots, depending on the state of the tidal-cycle. These velocities are representative of average conditions in the relatively constricted passage through Cook Strait. It is reasonable to infer from this that the animals can maintain their position on the bottom despite the current. It may well be that the occurrence demonstrated a positive reaction in *Pyrosoma atlanticum* towards the least rapidly moving water in their immediate vicinity, since the whole water column above them would be moving at a greater rate.

The photographs for this work were taken by Mr. G. R. T. Clacey, of the New Zealand Electricity Department, with an underwater camera, developed in consultation with the New Zealand Oceanographic Institute and the Photographic Section of the Department of Scientific and Industrial Research.

D. E. Hurley
D. G. McKnight
New Zealand Oceanographic Institute,
Department of Scientific and Industrial Research,
P.O. Box 8009,
Wellington, New Zealand.

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Inhibitory Effect of Colchicine upon the Transplantable Fibroma of the Skin in the Newt *Triturus taeniatus*

Recently, we described a multiple fibroma of the skin in the newt *Triturus taeniatus* which was characterized by an enlargement of the adepidermal reticular network[1-4] and appeared to be transplantable in the same animal[3,4]. The preliminary transplantation experiments were continued to establish the effect of a colchicine treatment. The material for these experiments was obtained by breeding the normal animals of the first litter in which the tumour was observed[3,4]. Fragments of tumour tissue from the surroundings of small tumours, in which an enlargement of the nodular swellings of the adepidermal reticular network could already be expected, were transplanted to a perfectly tumour-free area of the same animal, preferably in the tail base region. In 105 of the 128 cases a distinct tumour developed after about 3 weeks at the location of the transplantation, whereas in the 23 negative cases the transplanted material had been almost completely resorbed. After 3 weeks in 83 of the 105 tumour cases treatment with colchicine was applied, the remaining 22 animals being used as controls. This colchicine treatment consisted in giving once a week an intraperitoneal injection of colchicine–saline solution (0·0017 mgm. colchicine). The method of preparing the solution for injection was as usual[5-7]. The experiment lasted 70 days.

Comparing the area diagrams which were made of the tumours, it was clear that the colchicine had an inhibitory effect on the growth of this fibroma.

The tumours of the colchicine-treated animals as well as of the control animals were examined histologically, and particularly the adepidermal reticular network was studied with the aid of Pap's ammoniacal silver method as modified by Mitchell and Wislocki[8] (counterstain paracarmine) and Bodian silver–proteinate (counterstain orange *G*).

The tumours of the control animals showed the normal development of this fibroma, in which the following stages already described[3,4] were observed: (1) enlargement of the nodular swellings of the adepidermal reticular network; (2) continued enlargement of the nodular swellings and concentration of fibroblasts in their surroundings; (3) formation of new fine fibrils radiating from the enlarged nodular swellings, a densely structured network thus being formed around the concentrated fibroblasts; (4) fusion of the concentrated masses of fibroblasts to larger complexes. The enlarged nodular swellings are probably induction centres which, with the aid of certain chemical substances, cause the local concentrations of the fibroblasts.

In the tumours of the colchicine-treated animals particularly the enlargement of the nodular swellings and the concentration of the fibroblasts appeared to be disturbed. The inhibitory effect of the colchicine is consequently in all probability an inhibition of these processes. The fact that in the colchicine-treated animals these processes, as well as the tumour growth, had come to a stop is an important argument for the assumption that these processes of the adepidermal reticular network play an important part in the development of this skin fibroma.

A. Stolk
Histological Laboratory,
The Free University,
Amsterdam. Dec. 20.

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Effect of Infection with Myxomatosis Virus on the Endoparasites of Rabbits

The widespread and common occurrence of endoparasites in free-living Australian wild rabbits, *Oryctolagus cuniculus* (L.), prompted an investigation into any effect they might have on the severity of infectious myxomatosis in partially resistant animals, or in cases due to attenuated strains of the virus. Although the results so far obtained are based on a small number of rabbits and are insufficient to answer this complicated problem fully, results collected simultaneously on the behaviour of parasites, especially *Graphidium strigosum*, in virus-infected hosts are interesting and worth recording.

Rabbits infected naturally with *Eimeria* spp. (coccidia), *G. strigosum*, and *Trichostrongylus retortaeformis* were caught in the field at the approximate age of six weeks for the purpose of testing for the degree of genetic resistance to myxomatosis. Prior to inoculation with *K.M.* 13 attenuated strain of virus[1] at about five months, they were kept in the laboratory under conditions which excluded the possibility fo re-infection. For one week before inoculation, and then throughout the course of the disease, fæcal counts of oocysts and nematode eggs were carried out at 2-day intervals in 12 rabbits.

Statistical analysis of the results showed that after generalization of the virus in the host, seven days after inoculation, a significant ($P < 0{\cdot}05$) reduction in the numbers of oocysts and ova occurred, which lasted for approximately 2 weeks—a period coinciding with the acute stage of the disease. The reason for this was not studied specifically, and it is only suggested that the changing metabolism in the host or its increasing body temperature may have induced conditions unsuitable for the development of the parasites. Similarly, Reid *et al.*[2], studying the effects of *Ascaridia galli* on chicks with infectious bronchitis, recently reported a highly significant reduction of worms due to the virus infection; and common observation suggests that the burden of worms decreases markedly in dogs affected by distemper (Soulsby, E. J. L., personal communication).

After the reduction induced by the virus infection a significant ($P < 0{\cdot}05$) increase was recorded generally in numbers of ova but not of coccidia. In only a few animals were counts unchanged—these survived, whereas all those showing an increase died, some when complete recovery from myxomatosis had been expected. Post-mortem examination revealed that the level of infestation with *G. strigosum* was very high in some animals; more than 5,000 worms per rabbit were counted in some cases—a degree of infestation not previously recorded in large samples of normal rabbits caught in the field[3]. These worm populations consisted of newly hatched adults and fourth-stage larvæ, in spite of the fact that all rabbits had been protected from re-infestation with endoparasites.

Michel[4], while studying the problem of the resistance of rabbits to infestation with *T. retortaeformis*, found that in hosts already infested the development of superimposed larvæ is inhibited, and they remain dormant in the intestinal mucosa until conditions become more favourable. It seems that a similar mechanism operates in infestation with *G. strigosum*. The expulsion of adult worms during the early stages of infection with the virus, and the lowered resistance of the host due to the prolonged disease, probably create conditions under which dormant larvæ may resume development and so aggravate the severity of myxomatosis.

I reported earlier another form of interference between endoparasites and virus, which was manifested by inhibition of myxomatosis symptoms and premature death in heavily parasitized animals[5].

R. Mykytowycz

Commonwealth Scientific and Industrial Research
Organization,
Wildlife Survey Section,
Canberra, A.C.T.
Oct. 31.

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Long-term Survival of Irradiated Mice treated with Homologous Tissue Suspensions

Recently, Barnes *et al.*[1] reported the survival for 150 days of *CBA* mice subjected to a dose of 950 r. X-radiation and treated with spleen or liver suspensions from new-born or unborn *C57BL* mice. In an attempt to clarify the secondary phase of the irradiation death syndrome, Uphoff[2] observed the 90-day survival of $(C57BL \times DBA/2)F_1$ hybrids subjected to 800 r. X-radiation following injections of suspensions made from *C57BL* or *DBA*/2 tissues. She reported that the use of fœtal hæmatopoietic tissues precluded the secondary phase of the irradiation syndrome for 90 days after irradiation, whereas injection of bone marrow suspensions did not.

Table 1. Effect of *CF* No. 1, *C57BL*/6, or LAF_1 Tissue Suspensions on Survival of 10- to 12-week-old *CF* No. 1 Female Mice exposed to 750 r. Total-body X-radiation.
Controls consisted of 10 untreated *CF* No. 1 mice, all of which survived 270 days; 9 survived 400 days and 7 survived 500 days; 2 were still alive at 910 days

Donor tissue	No. of mice treated	No. surviving at intervals shown (days) 28	150	270	400	500	Day of last death
CF No. 1 bone marrow (7- to 8-week mice)	36	23	20	17	8	2	515
C57BL/6 bone marrow (7- to 8-week mice)	36	3	0	0	0	0	121
CF No. 1 baby spleen	44	24	16	9	4	1	525
C57BL/6 baby spleen	50	30	9	5	1	0	406
LAF_1 baby spleen	34	18	11	6	2	0	483
CF No. 1 embryo liver	45	34	31	24	16	1	546
C57BL/6 embryo liver	69	27	18	11	2	1	497
Locke's solution	75	5	3	1	0	0	365

In 1956 [3] we observed that no secondary deaths occurred when lethally irradiated rabbits were injected with embryonic or new-born mouse tissues, and that rabbits so treated were alive after 150 days. Many of these rabbits are, in fact, still alive after three and a half years. We had previously reported in 1954 [4] that suspensions made from fœtal *CF* No. 1 mouse liver, or spleen and liver from new-born mice, were more effective, on the basis of cell counts, than suspensions of mature tissue in enhancing the 30-day survival of irradiated (900 r.) mice of the same strain. *CF* No. 1 mice which were treated with hæmatopoietic tissues from young or unborn *CF* No. 1, *C57BL*/6, or LAF_1 mice following 750 r. total-body X-irradiation have now lived out their life-span, and the long-term survival results are shown in Table 1. Irradiated *CF* No. 1 mice survived longer when injected with fœtal liver or spleen suspensions from new-born mice than when treated with an equal number of *C57BL*/6 or *CF* No. 1 bone marrow cells.

Although the *CF* No. 1 strain is no longer maintained by strict inbreeding, post-irradiation treatment with *CF* No. 1 fœtal or new-born tissues resulted in longer survival than did similar treatment with *C57BL*/6 or LAF_1 tissues.

Eric L. Simmons
Leon O. Jacobson
Edna K. Marks
Evelyn O. Gaston

Argonne Cancer Research Hospital*,
and
Department of Medicine,
University of Chicago,
Illinois.
Oct. 6.

* Operated by the University of Chicago for the United States Atomic Energy Commission.

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Red Muscle as a Possible Character for the Identification of Sharks

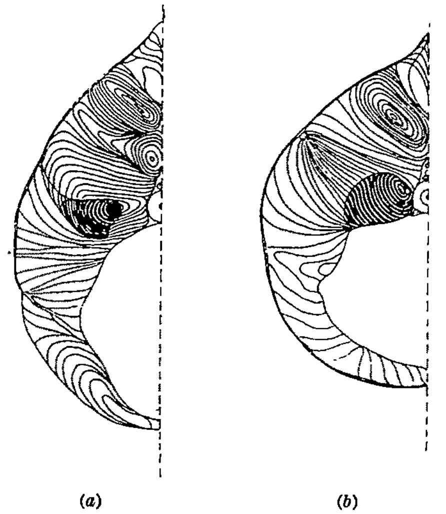
In a previous communication, the relative distribution of vitamins between the red muscle and the ordinary muscle in fish was reported[1]. The relation between the proportion of red muscle present and the activity of different species was pointed out, and the possible function of the red muscle as an organ proposed.

Since then studies have been in progress, including recording the extent of the red muscle in the different species investigated. By chance these studies have led to an interesting observation in the two closely related pelagic sharks of the family Isuridae or mackerel sharks.

The main studies were carried out with the porbeagle (*Lamna nasus*[2], syn. *Lamna cornubica*[3] or *Isurus nasus*[4,5]), the mackerel shark caught off the coast of Norway. Although this species is caught also in the warmer parts of the Atlantic and in the Mediterranean, it seems present mainly in the northern part of the Atlantic. The very closely related sharp-nosed mackerel shark or mako (*Isurus oxyrinchus*) lives mainly in the warmer parts of the Atlantic and is very rarely caught off the coast of Norway or in the north.

The two species are very alike, but certain distinctive characters, such as the teeth and the position of the dorsal and ventral fins, can be used for their identification. The porbeagle also has a stouter trunk than the mako. They are both very active and strong-swimming species which prey mainly upon shoals of scombroids, clupeids and other small fishes.

By chance a 'trunk' of a mackerel shark caught off the coast of Morocco was brought to this Institute for comparison with regard to palatability and quality with the porbeagle caught off the coast of Norway. During routine sampling and recording of the red muscles of these sharks, a very typical difference in the location of the red muscle in the two species was observed. While the red muscles in the porbeagle only extended partly along the trunk and were mainly situated close to the vertebra and the body-cavity, the red muscles in the mako extended all along the trunk and did not lie directly up against the vertebra. Fig. 1 shows transverse sections of the two species at the thickest part of the red muscles. Both fishes had a gutted weight of 13 kgm. Differences caused by stages in development thus could be discounted. Both species are very alike, and it is actually very difficult to identify them as delivered at the fish market, although the transition from stone-grey colour on the dorsal to white on the ventral side changes abruptly on the porbeagle and gradually on the mako. The present observation shows that the position of the red muscle in this case gives a good character for the distinction between closely related species. To my knowledge, this character has never been proposed or used for identification purposes in fishery research. It is apparently specially useful for pelagic species with distinct red muscles. The usefulness of the proposed character will have to be established by further investigations by marine biologists working in this field.



(*a*) (*b*)

Fig. 1. Transverse sections of the sharks: left, mako (*Isurus oxyrinchus*); right, porbeagle (*Lamna nasus*), showing the position of the red muscles

I wish to express my thanks to Mr. Gunnar Rollefsen, director of marine research, for encouraging discussions, and to Mr. Klaus Olsen, fish inspector at the Directorate of Fisheries, for supplying the specimens.

Olaf R. Brækkan
Governmental Vitamin Laboratory,
Norwegian Fisheries Research Institute,
Bergen, Norway. Dec. 19.

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Origin of Indirect Flight Muscles in Primitive Flies

It is generally supposed that among endopterygote insects the flight muscles of the adult first arise in the pupal stage. For example, in the higher Diptera (*Drosophila*[1,2], *Calliphora*[3]) the development of the indirect flight muscles is said to begin at pupation when free myoblasts adhere to or penetrate certain larval muscle fibres. In the early pharate[4] pupa of the Neuroptera[5] and Coleoptera[6,7], larval muscle is directly transformed into adult muscle: in certain larval muscles some nuclei degenerate and others undergo mitosis and persist as the nuclei of the adult flight muscle. In some Hymenoptera (*Mormonella*[8]) the adult muscles arise from free myoblasts as in the higher Diptera, whereas in others, such as the honey-bee[9], the imaginal myoblasts are contained in the larval muscle, as in the Neuroptera and Coleoptera.

In the Simuliidae, however, the indirect flight muscles and the tergal depressor of the trochanter develop quite independently of the larval muscles in all post-embryonic stages. So far as may be judged from the account given by Hulst[10], the indirect flight muscles of *Culex* also develop independently of the larval muscles. In the mesothorax of the Simuliidae there are six groups of indirect flight muscles. These consist on each side of 6 dorso-longitudinal, 2 oblique dorsal, 2 tergo-meral, 2 tergo-sternal, 3 outer tergo-pleural, and 2 inner tergo-pleural. In *Simulium ornatum* Meig., in which there are six larval instars, the imaginal disks of the indirect flight muscles and that of the tergal depressor of the trochanter are present in the second instar larva 1·3 mm. long. In the first instar larva the disks of the dorso-longitudinal muscles are present but those of the dorso-ventral muscles have not yet been identified with certainty.

In the young larva the disks of the indirect flight muscles consist of slender strands attached at either end to the epidermis but not to the cuticle (Fig. 1). Each of these strands is a sleeve of sarcolemma enclosing a syncytium with a few nuclei. The strands grow in length and thickness as the larva grows so that their size relative to that of the mesothorax is maintained. The nuclei are similar in size in all

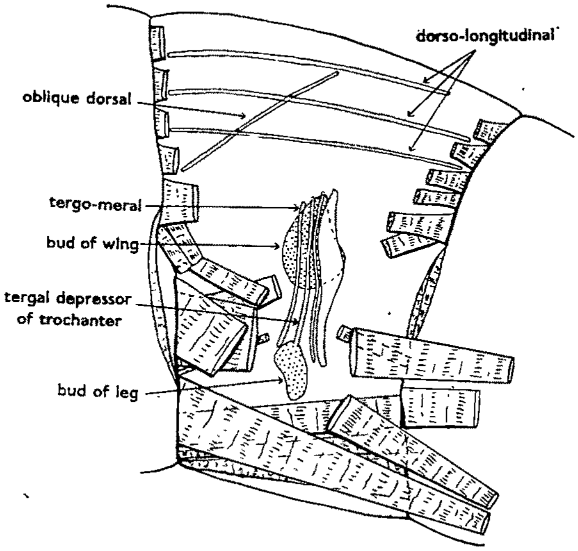

Fig. 1. Mesothorax of penultimate larval instar of *Simulium ornatum* Meig. Larval muscles shaded, disks of imaginal muscles unshaded

larval stages : 4–6μ. In very young larvæ the strands are often thinner than the nuclei so that they bulge where nuclei are present. As the larva grows the number of nuclei increases by mitosis. The mitotic divisions appear indistinguishable from those of the epidermis.

After the larval–pupal moult but before the larval–pupal ecdysis, that is, in the pharate[4] pupal stage, there is a rapid increase in the size of the imaginal strands, and mitotic figures are numerous both during the day and the night. Before the larval cuticle is shed, mitosis appears to have come to an end, and the nuclei have become arranged in longitudinal rows. Also before the larval–pupal ecdysis the imaginal strands have become divided so that there are now clearly 17 on each side plus the tergal depressor of the trochanter. It is during the pharate pupal period that differences between the organization of the fibrillar tergal depressor of the trochanter and the indirect flight muscles are first discerned. The indirect flight muscles and the tergal depressor of the trochanter continue to grow in size after the larval cuticle is shed and after the pupal–adult moult. At this time growth in volume is accompanied by a degeneration of the nuclei.

In the young pharate pupa the shape of the thorax and the relative proportions of its three segments are as in the last larval instar. The great increase in the extent of the mesothorax and the great reduction in the extent of the pro- and meta-thorax occur during the pharate pupal period, especially near the end of this period. The epidermis of the thorax assumes its final 'humped' shape at the moment that the larval cuticle is being shed, and it is this change in shape that effects the first split in the larval cuticle. The change in shape is brought about by an increase in turgor pressure due to the contractions of the muscles carried over directly from the larval stage, but it is made possible by the enormous increase in area of the mesothoracic epidermis that occurs after the larval–pupal moult but before the larval cuticle is shed. After the larval–pupal ecdysis, the shape of the thorax is essentially that of the adult, although in some other Nematocera, such as the Thaumaleidae[11], the metathorax is reduced in the pharate pupal period and the prothorax in the pharate adult period.

The indirect flight muscles and the tergal depressor of the trochanter do not become contractile, cross striated, or birefringent until some hours after the first layers of the adult cuticle have been secreted. It therefore follows that they can play no direct part in the change of shape that occurs when the pupa sheds the larval cuticle, as they have been said to do in *Drosophila*[12]. During growth the muscles do not shift their attachments to the epidermis, but the epidermis of different parts of the mesothorax grows at different rates. It is this differential growth of the epidermis that directly determines changes in the position and orientation of the indirect flight muscles, changes that are particularly evident as the newly enlarged epidermis of the mesothorax is stretched during the shedding of the larval cuticle. So far as the mesothorax is concerned, all larval muscles except one are carried over without evident modification into the pupal stage, and no new muscles that function in the pupal stage are developed in that stage. Histolysis of the larval muscles becomes evident only in the pharate adult stage, and their destruction is not completed until about 30 hr. (at 8° C.) after the pupal–adult moult.

In some other Diptera–Nematocera the indirect flight muscles would appear to develop in a similar way. The imaginal disks of the dorsal longitudinal or both dorsal longitudinal and dorso-ventral muscles have been identified in the last larval instar of the Tipulidae (*Taphrophila*, *Geranomyia*), Dixidae, Culicidae (*Aedes aegypti* L.), Chironomidae (*Chironomus*), and Thaumaleidae.

H. E. HINTON

Department of Zoology,
University of Bristol.
Dec. 30.

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Goniotrichum elegans: a Marine Red Alga requiring Vitamin B_{12}

THE cultivation of multicellular marine algae under laboratory conditions has always proved to be a matter of difficulty. Most species die after a few months even if cultivated in seawater or enriched seawater. Henkel[1] succeeded in cultivating *Bangia pumila* through several generations in an artificial medium, but she did not work with pure cultures. Koch[2] produced an axenical culture of *Porphyridium cruentum*. His medium was not, however, chemically defined since it contained natural water.

I have tried to cultivate several marine algae in completely defined nutrient medium. To that purpose medium *ASP* 6 was used[3], but without copper and cobalt, and with potassium-glycerophosphate replaced by 10 mgm. dipotassium hydrogen phosphate per litre. *Goniotrichum elegans* (Chauv.), a small epiphytic member of the Bangioideae with a

Table 1. GROWTH OF *Goniotrichum elegans* WITH COBALT OR VITAMIN B_{12}

The figures represent the total dry weight produced in all six flasks of each series. Incubation time, 4 weeks

No addition	Dry weight of alga (mgm.)	
	Cobalt (10 μgm./l.)	B_{12} (1 μgm./l.)
0·9	0·7	6·9

dichotomously ramified monosiphonous thallus, was among the species treated. It produced good growth in *ASP* 6, and since May 1957 it has been cultivated through repeated re-inoculations in 100-ml. 'Pyrex' flasks with 25 ml. nutrient solution per flask, in fluorescent light (900 lux) at 20° C. Diatoms and other small algae were removed by washing and careful manipulations. By treating small samples of the alga with phenoxymethylpenicillin (1,000 units per ml.) combined with streptomycin sulphate (Glaxo, 500 units per ml.)[4] of contaminating bacteria were killed and a completely axenical culture was obtained. The treatment had to proceed for 12–14 days to give a satisfactory result. The purity has repeatedly been controlled according to the test described by Pringsheim[5]. When it was used in the following experiments the strain had remained axenical for 3½ months.

The requirement of growth substances was studied. The medium *ASP* 6 contains all available vitamins. In the first experiment the exclusion of the vitamins did not seem to slow down growth. The experiment was repeated, however, and as inocula the algae from the vitamin-free series of the former experiment were used. The following series were inoculated: (*a*) without vitamins; (*b*) with B_2, B_{12}, pyridoxamine and folic acid, run through sterile glass filter and added aseptically; (*c*) with the remaining 11 vitamins, sterilized together with the nutrient solution. Visible growth appeared only in series *b*.

Several marine algae and bacteria have turned out to be dependent[6] on an exogenous source of vitamin B_{12}. This vitamin was therefore suspected to be the active member of the vitamin mixture. Since in all experiments hitherto no cobalt had been added to the nutrient solution, there was a possibility that B_{12} acted only as a cobalt source[7]. In a following experiment cobalt (10 μgm. per litre) and B_{12} (1 μgm. per litre) were added to two different series (Table 1). As inocula, pieces of *Goniotrichum* from the vitamin-free series of the preceding experiment were used, which had been cultivated for 50 days, and during this time transferred three times into new cobalt- and vitamin-free nutrient solution. The inocula were pale and partly dead.

As Table 1 shows, good growth appeared only in the B_{12} series, while the addition of cobalt had no effect. Ericson and Lewis[8], who worked with labelled cobalt and B_{12}, found that some red algae could transfer cyanocobalamin into other B_{12} factors, though additions of B_{12} gave no stimulation. They assumed that B_{12} was produced by bacteria and then accumulated by the algae, but they had no proof of the vitamin being necessary for the algae as they did not work with pure cultures. The experiments with *Goniotrichum elegans* thus add a member of the Rhodophyta to the list of vitamin B_{12} heterotrophic algae. Pintner and Provasoli[9] have shown that a marine red pigmented blue-green alga, *Phormidium persicinum*, also needs exogenous vitamin B_{12}. This similarity of vitamin requirement may perhaps support the theory of a relationship between blue-green algae and red algae.

LISBETH FRIES

Institute of Physiological Botany,
University of Uppsala.
Dec. 9.

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Effect of Boron on the Rooting of Clematis Cuttings

BORON has been observed to stimulate the rooting of large-flowered hybrid clematis cuttings. In two studies recently carried out, increased percentages of cuttings rooted and the rooting process was accelerated by boron when it was used in combination with the root-initiating hormone, indole butyric acid.

Previously, stimulation by boron of the rooting of *Phaseolus vulgaris* L. cuttings was noted by Hemberg[1] and verified by Gorter[2]. Although relatively little is known about the nature of this stimulative action, Hemberg[1] and Rehm[3] have stated that root growth, and not root initiation, is favoured by this element.

In the first study, 180 two-node cuttings were taken on June 14, 1958, from new growth of clematis selection 234, a seedling of Crimson Star. Cuttings were divided into four lots of 45 each and the bases of the cuttings in each of these lots were soaked for 12 hr. in one of the following aqueous solutions: 50 p.p.m. indole butyric acid; 50 p.p.m. boron, supplied as boric acid; 50 p.p.m. indole butyric acid plus 50 p.p.m. boron; and water. Following these treatments the cuttings were placed in washed sand on the propagating bench under an intermittent mist system which came on for 15 sec. out of every 3 min. during the daylight hours. The temperature of the sand was maintained at approximately 75° F. by heating cables. Air temperature was 65° F. at night and usually higher during the day, occasionally reaching a maximum of 85° F.

The percentage of cuttings rooted in each treatment after 32 days and after 54 days is recorded in Table 1.

Table 1. RESPONSE OF CLEMATIS SELECTION 234 TO THE ROOTING TREATMENTS

Treatment	Rooting	
	After 32 days (per cent)	After 54 days (per cent)
Water	6·7	33·3
Indole butyric acid	24·4	55·6
Boron	17·8	62·2
Indole butyric acid + boron	66·7	86·7

It is evident from these figures that boron stimulated the rooting of cuttings when it was used in combination with indole butyric acid, and to a lesser extent when it was used alone. A comparison of the rooting percentages at the two observation dates indicates indole butyric acid plus boron accelerated rooting in addition to increasing the percentage of cuttings which rooted.

Table 2. RESPONSE OF NINE CLEMATIS SELECTIONS TO THE ROOTING TREATMENTS

Selection No.	Rooting after 36 days			
	Water (per cent)	Indole butyric acid (per cent)	Boron (per cent)	Indole butyric acid + boron (per cent)
181	100	60	80	90
51	60	80	20	90
217	0	50	20	100
169	20	40	40	50
31	80	90	100	90
32	80	90	60	80
94	0	70	0	100
54	40	60	40	70
159	40	80	40	90
Treatment average after 36 days	46·7	68·9	44·4	84·4
Treatment average after 56 days	53·3	74·4	53·3	85·6

In the second study 30 two-node cuttings were taken on July 24, 1958, from each of 9 numbered clematis selections of diverse parentage and were given the four treatments described in the first study. Cuttings were divided into lots of unequal size so that 10 cuttings of each selection received the indole butyric acid and indole butyric acid plus boron treatments while 5 cuttings of each selection received the boron and the water treatments. The rooting conditions on the cutting bench were the same as those described in the first study. Table 2 shows the treatment averages after 36 days and 56 days and the percentage rooting of each selection after 36 days.

Selections varied considerably in response to the treatments, but the treatment averages in general substantiated the results obtained in the first study. In particular, the high rooting percentage of the indole butyric acid plus boron treatment and the acceleration of the rooting process by the boron in that treatment agreed with the results of the former study. A notable exception is the lack of increased rooting in the boron treatment as compared with the water check. This lack of increased rooting seems to support the views of Rehm[3] and Hemberg[1] that boron promotes root growth and not root initiation. If applied to the indole butyric acid and indole butyric acid plus boron treatments, this concept implies that cuttings in both treatments may have formed the same number of root initials as a result of the initiation stimulus of indole butyric acid, but that more roots grew in the treatment with indole butyric acid plus boron due to the growth stimulus of boron. Nevertheless, other possible explanations of this boron stimulation, such as a boron enhancement of the effectiveness of indole butyric acid in stimulating root initiation, seem equally plausible in these studies. Further investigation is necessary to elucidate the role or roles of boron in rooting cuttings.

Results of studies which indicate that boron also enhances the rooting of cuttings of certain varieties of rhododendrons and English holly (*Ilex aquifolium* L.) will be published elsewhere.

I am indebted to Dr. L. T. Blaney for his helpful suggestions.

C. J. WEISER

Department of Horticulture,
Oregon State College,
Corvallis, Oregon.
Dec. 18.

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[1] Hemberg, T., *Physiol. Plant.*, **4**, 358 (1951).

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Crowned Cranes in Cambridgeshire

FOUR crowned cranes (*Balearica pavonina*) recently appeared in an area of arable and marshy country in Cambridgeshire. This species, so far as we know, has not previously been described as occurring at large in Britain, although one specimen was shot in Ayrshire in 1871, and had "doubtless escaped from captivity"[1].

The birds appeared in their present haunts in August 1958, or possibly earlier. They were last seen on January 24. Two were adult; the other two, from their more buff-coloured plumage, appeared to be immature.

All exhibited the straw-coloured crown characteristic of the species and the elongated secondaries typical of cranes. The white facial patch behind the eye was very conspicuous; the red area behind it was clearly seen but more difficult to define. The neck appeared dark grey or black according to the lighting.

In flight the neck and legs were extended, and with the back, formed a dorsal convex curve. The crown was laid close to the neck. The large white wing was edged at the tip and along its hind margin with black primaries and secondaries. It presented a digitated appearance at its extremity. A gap in the secondaries could be seen when the wing was viewed from below. The birds' flight was powerful and at times swift, direct and purposeful when compared with that of the heron. Landing was preceded by a glide, and lowering the legs produced a braking effect by opposing the under surface of the wings to the direction of flight. The birds were usually seen flying in line ahead, and any tendency for the group to become split up was checked by a repeated honking call from the leader.

Owing to the wet summer in 1958, several fields of barley in the locality now frequented by these cranes were left unharvested. They have been commonly observed feeding on the uncut barley and gleaning among the stubble.

They were alert and very shy, and careful stalking has been required to approach within fifty yards. On taking wing they travelled 400–1,000 yards and then once more alighted to continue feeding. Once the larger of the two adults was seen to perch on a tree, where it acted as sentinel. The remaining three partially concealed behind a broken hedge could be seen with necks craned in a characteristic posture.

From their extreme wariness we do not believe that these birds have escaped from captivity; but this cannot be ruled out without a complete record of recent escapes of this species. We have now had them under observation for more than two months and attempts to photograph them, with or without 'hides', have met with little success. We should add that since January 10 only three cranes have been seen; the fate of the fourth, an immature bird, is unknown.

We are indebted to Prof. R. A. McCance for valuable help and advice.

SIMON B. JONES
PHILIP E. H. JONES

The Harrow,
Fulbourn,
Cambridge.
Jan. 30.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 23

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. G. D. Pratt and Dr. Hal Lister: "Glaciological Research on the Trans-Antarctic Expedition".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

University of London Institute of Education (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Dr. R. S. Peters: "Education and Explanation—an Examination of Ways in which Theories of Learning are Relevant".*

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. E. W. Montroll (University of Maryland): "Theory of Vibration of Crystal Lattices".* (First of three lectures on "Statistical Mechanics". Further lectures on February 24 and 25.)

Institut Francais du Royaume-Uni (at Queensberry Place, South Kensington, London, S.W.7), at 8.30 p.m.—Programme of French Scientific Films. (By invitation obtainable from the Scientific Office, French Embassy, 22 Wilton Crescent, S.W.1).

Tuesday, February 24

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. W. B. Emery: "Excavations at Buhen, Sudan".*

University College (in the Anatomy Theatre, Gower Street London, W.C.1), at 5.30 p.m.—Prof. G. C. Drew: "Aspects of the Investigation of Skilled Performance".*

Society of Instrument Technology, Control Section (at Manson House, Portland Place, London, W.1), at 6 p.m.—Symposium on "Automatic Weight Control in Industry".

Society for Analytical Chemistry, Physical Methods Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "The Analysis of Intact Samples".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. A. E. Russell, Mr. C. Abell and Dr. E. Warlow-Davies: "The Flight Development of an Aircraft Before and During its Operation".

Wednesday, February 25

Geological Society of London (at Burlington House, Piccadilly, London, W.1.), at 5 p.m.—Dr. J. L. Knill: "The Tectonic Pattern in the Dalradian of the Craignish–Kilmelfort District, Argyllshire"; Dr. P. Clifford: "The Geological Structure of the Loch Luichart Area, Ross-shire" (to be read by Prof. J. Sutton).

Royal Society of Medicine, Endocrinology Section (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "The Chemical, Pharmacological and Clinical Aspects of the 19-nor-steroids". Opening Speakers: Dr. W. Klyne, Dr. J. C. Eaton, Dr. T. M. Chalmers, Dr. G. I. M. Swyer, Dr. Margaret C. N. Jackson and Mr. J. A. Chalmers.

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr.-Ing. H. Lent: "Investigations in Germany concerning Atmospheric Pollution".*

Institution of Mechanical Engineers, Applied Mechanics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Significance of Thermal Stresses in Design".

Society of Chemical Industry (joint meeting of the Food Group and the Microbiology Group, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "Cheese Manufacture and Microbiology". Dr. K. Mabbit: "Microbiological Aspects"; Miss V. Cheke: "Technological Aspects".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. E. D. Swann: "Patents and the Radio Engineer".

Oil and Colour Chemists' Association (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. D. M. James: "The Moisture Resistance of Cold-Cured Epoxide Resin Paints".

British Psychological Society, Social Psychology Section (at Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Annual Meeting. Paper by Prof. Angus Campbell.

Thursday, February 26

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. K. A. Sinnhuber: "Alexander von Humboldt (d. 1859), Traveller, Geographer, Philosopher".*

Institution of Industrial Safety Officers (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 2.30 p.m.—Mr. R. E. Tugman, M.B.E.: "The Responsibility of Management for the Prevention of Industrial Accidents" (First Alexander Redgrave Memorial Lecture).

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Miss Ann B. Glossop and Mr. D. W. Pashley: "The Direct Observation of Anti-phase Domain Boundaries in the Ordered Copper-Gold (Cu-Au) Alloy"; Mr. J. Grindlay and Mr. D. ter Haar: "On the Ferro-electric Behaviour of Potassium Dihydrogen Phosphate".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. Peter David: "Exclusive Distribution of Certain Species of Chaetognaths"; Dr. M. H. Williamson: "Effects of Inter-Specific Competition".

Physical Society, Acoustics Group (at the Royal Academy of Music, Marylebone Road, London, N.W.1), at 5.30 p.m.—Discussion on "Of What Use is Acoustics to the Musician?"

Chemical Society (in the Lecture Theatre, The Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Prof. F. Hoyle, F.R.S.: "The Origin of the Elements".

Friday, February 27

Institute of Rural Life at Home and Overseas (at Friends International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—Mr. C. W. A. Garland: "Higher Education in British Africa".*

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Characteristics of the Antarctic Ice Sheet". Chairman: Dr. J. F. Nye. Speakers: Monsieur B. Imbert, Dr. H. Lister and Mr. J. G. D. Pratt.*

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Informal Discussion on "Choice of Gas Temperature and Steam and Pressure Conditions in Nuclear Power Stations".

Malacological Society of London (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Discussion on "The Status of the Protobranchia within the Bivalve Mollusca".

Manchester Statistical Society, Industrial Group (in the Portico Library, 57 Mosley Street, Manchester), at 6 p.m.—Dr. A. Baines: "Applications of Linear Programming Techniques to Problems of Production and Distribution".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. C. H. Waddington, F.R.S.: "Evolutionary Systems—Animal and Human".

Saturday, February 28

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Guy Atkins: "African Sculpture and Western Art".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer in Microbiology—The Secretary, The Queen's University, Belfast (February 28).

Research Fellow in the Department of Pharmacology—The Secretary, Royal Free Hospital School of Medicine (University of London), 8 Hunter Street, London, W.C.1 (February 28).

Assistant (with an honours degree in physiology or an allied subject and preferably a medical degree) in the Department of Physiology—The Secretary, The University, Edinburgh (March 1).

Assistant Lecturer, Grade B (with qualifications in numerical analysis) in the Department of Mathematics—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (March 2).

Scientist (with at least a second-class honours degree or equivalent) at the Research and Development Laboratories, Capenhurst, Chester, to work on the development of infra-red absorptiometers and on allied infra-red and optical instrumentation problems, involving the design and use of optical and infra-red systems, techniques of absorption spectroscopy and application of modern electronic methods—The Recruitment Officer, U.K.A.E.A., I.G.H.Q., Risley, Warrington, Lancashire, quoting Ref. 2938/114 (March 2).

Lecturer or Senior Lecturer in Mathematics at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 6).

Assistant Lecturer (with a good honours degree in agricultural chemistry, chemistry or physics, and preferably an interest in soil physics) in Agricultural Chemistry—The Registrar, The University, Leeds 2 (March 11).

Lecturer or Assistant Professor (with a Ph.D. degree in mathematics or in applied mathematics)—The Chairman, Mathematics Department, McMaster University, Hamilton, Ontario, Canada (March 15).

Reader in Bacteriology at St. George's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 16).

Reader in Morbid Anatomy at St. George's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 16).

Assistant Lecturer (with special qualifications in micropalæontology) in the Department of Geology—The Registrar, University College of Wales, Aberystwyth (March 21).

Lecturers or Assistant Lecturers in the Department of Physics—The Registrar, The University, Leeds 2 (March 21).

Mullard Research Fellow (preferably with a Ph.D. degree or equivalent research experience) in Physics—The Registrar, University College of North Staffordshire, Keele, Staffs (March 30).

Chair of Bacteriology in the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 31).

Chair of Engineering; Chair of Chemistry; Chair of Biology; Vice-Chancellor; and Librarian at Monash University, Melbourne, Victoria, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (March 31).

Lecturer (preferably with experience in semiconductor applications or electronic computers) in Light Electrical Engineering—The Secretary, The Queen's University, Belfast (March 31).

Principal (with high academic qualifications and appropriate educational and administrative experience)—Clerk to the Governing Body, Northern Polytechnic, Holloway, London, N.7 (March 31).

University Demonstrator (with an honours degree in zoology) in Zoology—The Secretary of the Appointments Committee of the Faculty of Biology "A", Botany School, The University, Downing Street, Cambridge (March 31).

Assistant Lecturer (with appropriate qualifications, specializing in either pure or applied mathematics) in Mathematics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, April 3).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Chemotherapy, Engineering, Metallurgy, Pharmacology or Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Turner and Newall Research Fellows in Engineering, Inorganic Chemistry or Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Assistant Lecturer in Mathematics—The Secretary, Royal College of Science and Technology, Glasgow.

Associate Professor of Pharmacology—The Dean of Medicine, University of Alberta, Edmonton, Alberta, Canada.

Head (man or woman) of the Department of Chemistry—The Headmaster, Weymouth Grammar School, Weymouth, Dorset.

Junior or Student Technician (preferably with experience in histological work and/or microphotography) in the Anatomy Department—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

Lecturer in Telecommunications, to teach up to the full Technological Certificate of the City and Guilds of London Institute and the Grad.Brit.I.R.E.—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Lecturer or Senior Lecturer in Chemistry; and a Principal Lecturer in Education—The Warden, University of London, Goldsmith's College, New Cross, London, S.E.14.

Research Assistant (male or female) in Biochemistry, for work in the Research Laboratory—The Medical Superintendent, Western General Hospital, Crewe Road, Edinburgh 4.

Senior Lecturer (qualified to direct research and to teach to Honours Degree or Diploma in Technology levels, and preferably industrial experience in a responsible position) in Textile Physics—The Registrar, Institute of Technology, Bradford 7.

Senior Lecturer (with good academic qualifications, and experience in automatic control, preferably involving pneumatic or hydraulic systems) in Mechanical Engineering—The Registrar, Loughborough College of Technology, Loughborough, quoting Ref. 1/G.

Senior Technician or Chief Technician (preferably with experience in biochemistry), to work at Sheffield Royal Hospital—The Bursar, Department of Medicine, The University, Sheffield 10.

Teaching Assistants (qualified Ph.D. candidates)—Prof. H. B. Collier, Department of Biochemistry, University of Alberta, Edmonton, Alberta, Canada.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Laboratory Animals Centre. Collected Papers, Vol. 7, 1958: Report of a Symposium on the Organization and Administration of an Animal Division, held at the Royal Society of Medicine, London, 5th May 1958. Pp. 107. (Carshalton: Laboratory Animals Centre, 1958.) 10*s*. [1612

City of Leicester Museums and Art Gallery. 52nd Report to the City Council, 1st April 1957—31st March 1958. Pp. 35+4 plates. (Leicester: The Museums and Art Gallery, 1958.) [1612

University of Leeds. Publications and Titles of Theses, 1955–6. Pp. 74. (Leeds: The University, 1958.) 6*d*. [1612

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 991, Vol. 251 (4 December 1958): Storm Surges in the North Sea, 11 to 30 December 1954. By J. R. Rossiter. Pp. 139–160. 7*s*. No. 992, Vol. 251 (4 December 1958): The Geological Interpretation of Gravity and Magnetic Surveys in Devon and Cornwall. By M. H. P. Bott, A. A. Day and D. Masson-Smith. Pp. 161–191. 9*s*. 6*d*. (London: Royal Society, 1958.) [1612

Institution of Gas Engineers. 24th Autumn Meeting, London. Publication No. 532: 19th Report of the Chairmen's Technical Committee, 1957–58. Pp. 34. Publication No. 533: 35th Report of the Gas Education Committee, 1957–58. Pp. 33. Publication No. 534: Refractories Research in the Gas Industry. By Dr. A. T. Green. Pp. 26. Publication No. 535: The Influence of Frequency of Rotation on the Behaviour of Oxide Purifiers. By J. M. Brown, S. C. Porter and R. J. S. Thompson. Pp. 26. Publication No. 536: Experiences with Refinery Gas at Southampton. By W. F. Thorne, R. K. Harrison and J. R. Fairman. Pp. 64. Publication No. 537: Official Programme, 24th Autumn Research Meeting, London, 18th and 19th November, 1958. Pp. 8. (London: Institution of Gas Engineers, 1958.) [1612

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Session 1957–1958. Aden Protectorate. Pp. 20. 1*s*. Republic of the Sudan. Pp. 30. 1*s*. Uganda: Cotton Research Station, Namulonge and Cotton Breeding at Serere. Pp. 67. 1*s*. (London: Empire Cotton Growing Corporation, 1958.) [1612

Notes on the Library of the Royal Institution and a List of Periodicals and Serial Publications currently Received. Pp. 28. (London: Royal Institution, 1958.) [1612

Polish Cultural Institute. Selective Quarterly Guide to Polish Periodical Literature, Vol. III, 4, 1958. Pp. 50. (London: Polish Cultural Institute, 1958.) [1612

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 3 (No. 22): The Petrology of Picritic Rocks in Minor Intrusions—a Hebridean Group. By H. I. Drever and R. Johnston. Pp. 459–498+4 plates. (Edinburgh: Royal Society of Edinburgh, 1958.) 15*s*. [1612

Other Countries

Curator, Vol. 1, No. 1 (January, 1958.) (A quarterly publication of the American Museum of Natural History.) Pp. 96. Annual subscription: 5 dollars. (Special Charter Subscription Offer: Two years for 7.50 dollars.) (New York: The American Museum of Natural History, 1958.) [1612

Smithsonian Institution: Bureau of American Ethnology. Bulletin No. 168: The Native Brotherhoods: Modern Intertribal Organizations on the Northwest Coast. By Philip Drucker. Pp. iv+194. (Washington, D.C.: Government Printing Office, 1958.) 1 dollar. [1612

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Flore du Congo Belge et du Ruanda–Urundi. Spermatophytes. Tableau Analytique des Familles. Par W. Robyns. Pp. 69. Série Scientifique, No. 76: Symbiose *Rhizobium*—Légumineuses en Région Équatoriale (Deuxième Communication). Par Charles Bonnier et Jacques Seeger. Pp. 66. 80 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1958.) [1612

Durban Museum Novitates. Vol. 5, Part 9: Welwitsch's Bat *Myotis welwitschii* Gray, a Species New to the Fauna of Kenya Colony. By David L. Harrison. Pp. 111–115. 2*s*. 6*d*. Vol. 5, No. 10: Miscellaneous Taxonomic Notes on African Birds. By P. A. Clancey. Pp. 117–142. 5*s*. (Durban: Durban Museum, 1958.) [1612

United States Department of Agriculture. Production Research Report No. 18: Russian Thistle Distribution in Southern Idaho and Eastern Oregon in Relation to Beet Leafhopper Populations. By J. R. Douglass and H. C. Hallock. Pp. 20. (Washington, D.C.: Government Printing Office, 1958.) 10 cents. [1612

Suomen Geodeettisen Laitoksen Julkaisuja. Veröffentlichungen des Finnischen Geodätischen Institutes. No. 49: Die Zeiten von Sonnenschein, Dämmerung und Dunkelheit in Verschiedenen Breiten. Von Pentti Kalaja. Pp. 63. No. 50: Astronomische Azimutbestimmungen auf den Dreieckspunkten in den Jahren 1938–1952. Von V. R. Ölander. Pp. 90. (Helsinki: Finnischen Geodätischen Institutes, 1958.) [1612

Rules for the Preparation of Manuscripts and Bibliographies with a List of Abbreviations of Titles of Current Medical Periodicals. Pp. 18. (Basel and New York: S. Karger, 1958.) 0.50 dollars; 3*s*. 4*d*. [1612

Buletinul Institutului Politehnic din Iaso. Serie Noua. Tomul III (VII), Fasc. 3–4. Pp. viii+360. (Iasi: Institutului Politehnic, 1958.) [1612

Les Cahiers Techniques du Centre National de Co-ordination des Études et Recherches sur la Nutrition et l'Alimentation. No. 1: Méthodes d'Évaluation de la Valeur Nutritive des Protéines. Par Jean Adrian et Alain Rerat. Pp. vii+94. No. 2: Méthodes Indirectes de Mesure de la Graisse Corporelle des Mammifères. Par Bernard Louis Dumont. Pp. iii+95–158. (Paris: Centre National de la Recherche Scientifique, 1958.) [1612

Malaria Eradication: a Plea for Health. Pp. 12. (Geneva: World Health Organization, 1958.) [1612

The Egyptian Journal of Botany, Vol. 1, No. 1, 1958. Pp. ii+96. Annual Subscription: 100 P.T.; 21*s*.; 3 dollars. (Cairo: Botanical Society of Egypt, 1958.) [1612

Smithsonian Contributions to Astrophysics. Vol. 2, No. 13: Optical Properties of Saturn's Rings. 1: Transmission. By Allan F. Cook, II. and Fred A. Franklin. Pp. 377–383. (Washington, D.C.: Government Printing Office, 1958.) 20 cents. [1612

Bernice P. Bishop Museum, Honolulu. Bulletin 219: Subsistence Agriculture in Melanesia. By Jacques Barrau. Pp. iv+111. (Honolulu: Bernice P. Bishop Museum, 1958.) [1612

Fiskeridirektoratets Skrifter. Serie Havundersøkelser. Vol. 12, No. 2: The Herring from the Fuglsetfjord—a Supplement to "The Østerbø Herring." By Thorolv Rasmussen. Pp. 8+1 plate. (Bergen: A. S. John Griegs Boktrykkeri, 1958.) [1612

Symposium on Design for Tropical Living, Durban, 18th October, 1957. (Arranged by The Natal Regional Research Committee of the South African Council for Scientific and Industrial Research and the University of Natal.) Pp. vii+222. (Pretoria: South African Council for Scientific and Industrial Research, 1958.) [1612

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NATURE

No. 4661 SATURDAY, FEBRUARY 28, 1959 Vol. 183

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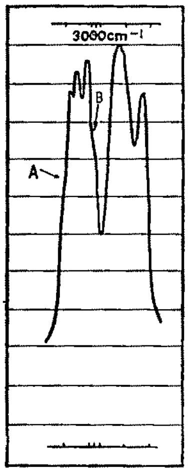
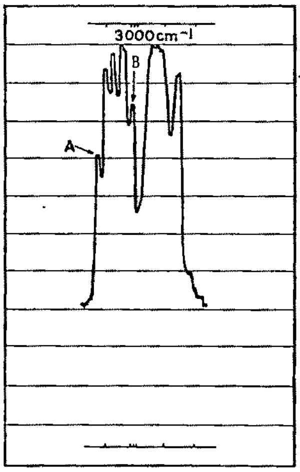


Fig. 1



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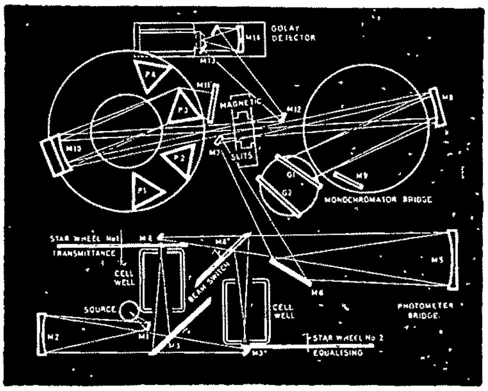

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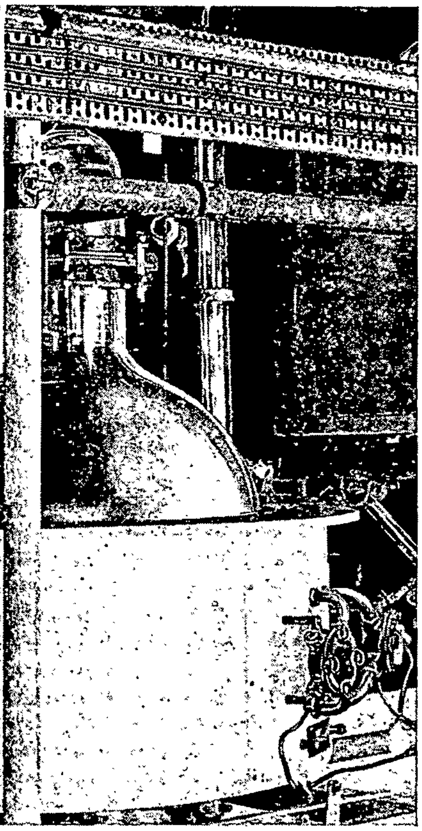

ORIGINAL RESEARCH AND ITS ENCOURAGEMENT

IN his latest report, Dr. Caryl P. Haskins, president of the Carnegie Institution of Washington, discusses further some of the problems presented to our times by the formidable diversities which characterize scientific effort. In his previous report he was concerned essentially with the challenges to communication and their implications for scientific institutions. In the present report, approaching the problem of innovation from an entirely different angle to Prof. J. Jewkes and his colleagues in "The Sources of Invention", he examines at some length the conditions most favourable to truly original investigation and the measures necessary to ensure that scientific originality continues to flourish in our society.

Once again Dr. Haskins begins with a brilliant and penetrating survey of the nature of scientific advance, which brings out the really vital factors—factors which tend to be over-shadowed by the very magnitude of scientific and technical effort to-day, when in 1958 American industry alone is estimated to be spending eight thousand million dollars on science and technology. These are massive and powerful factors shaping and seeking the opportunities for innovation, but they may not be ultimately the most significant of our time, though Dr. Haskins recognizes that the major revolutions in human thought are largely invisible to those who pass through them. Even the great tangible events that accompany such changes—the scientific conquests, the social upheavals, the political unrest and change—appear at the time largely as a series of striking but disconnected and disrupting events. In the perspective of three centuries, it is not very hard to see how interrelated were the turbulent material changes of the sixteenth and seventeenth centuries with the deeper revolutions of concept which accompanied them, or to realize how often inner revolution was reflected in the more material, more evident external one. We too may, Dr. Haskins suggests, be living in a time of remoulding of basic concepts that will ultimately be as fraught with opportunities for new exploration as was the scientific revolution of the sixteenth century.

Dr. Haskins's emphasis is on this note of opportunity. The greatest of man's advances are made, he maintains, not in the harshness of old necessity, but in the richness of new opportunity. Only to a limited extent does he believe that necessity is the mother of invention. With mankind, as with all living things, grinding hardship to the limit of endurance may be met by sinewy resistance, may lead to extraordinary heightening of old skills, to a marvellous sharpening and extension of well-tried modes of existence, but, in the larger sense, it may evoke little that is really new. "It is against the great and novel challenge, in fresh and unknown gardens of the intellect and spirit, that the mind of man has always found unrecognized powers, has always gleaned strength and courage and capacity to reach new worlds."

Because, therefore, every significant innovation brings new opportunity in its train, and that new opportunity in its turn breeds wider and more encompassing innovation, the very scale of scientific advances in the past few years brings an incomparable richness in opportunity for innovation, almost explosive in its dimensions. The revolutionary developments in nuclear physics and in relativity have made it clear that the succession of physical observations, the building of hypotheses to connect them, the elaborating of results predicted from those hypotheses, and the experimental testing of these results, while still the essential building stones of scientific inquiry, cannot, with only the older logic that has long connected them, comprehend the whole of Nature or be adequate to all the needs of science. A door has been opened on vistas so wide and unfamiliar that we may well be on the brink of a revolution in our notions of the nature of scientific truth itself. We may perhaps come to think of scientific truth primarily as a measure of the communicability and coherence of systems of thought, as a property of interchangeability between observers on one hand, and of scientific propositions between differing situations on the other.

If the old definition of the primary task of science as the search for truth is to retain its essential meaning, Dr. Haskins suggests we could then well say that the highest aim of scientific inquiry is to make knowledge communicable in all possible situations, and that knowledge shall be judged as 'true' by the degree of 'coherence' among such situations. This, of course, is a different aspect of the problem of communication from that discussed in his previous address; but at this point the two addresses are linked, for Dr. Haskins suggests that an essential core of such thinking, the concept of communication and communicability, may become one of the central ideas of science in the years to come, colouring all its concerns, from particle physics to the sciences of life and mind. Some indication that this is recognized can perhaps be traced in the proceedings of the International Conference on Scientific Information held at Washington last November.

It is out of the meeting of those new challenges and the embracing of the opportunities that the intellectual revolution, which Dr. Haskins predicts, will come, and it is because of them that he suggests there has never been a time richer in scientific opportunity. Nevertheless, truly great innovation remains a comparatively rare event, and Dr. Haskins is too wise to believe it can be organized. Even more important and striking is the rare and precious quality of the innovator himself, relative to the comparatively large and ever-growing number of fine minds devoted to science. He suggests that the opportunities for original advance have not been grasped as fully as they might well be, but his analysis is too penetrating for him to be led astray.

Others have also recognized that the intrinsic difficulty of great innovation and the various impediments to its communication are two reasons for its comparative infrequency. Prof. C. F. Carter and Prof. B. R. Williams, in "Industry and Technical Progress", were particularly concerned with means for removing impediments to communication. They also noted that the rate of technical change is limited by the number of good minds which can be brought to bear on the problems of research, of development and of management, and that this number is not capable of indefinite increase. Similarly, Prof. Jewkes and his colleagues, who, in asking the vital question whether Western societies are fully conscious of what they have been doing to themselves recently, come near the point of view of Dr. Haskins when they refer to the rashness of assuming that, because there are more people equipped with technical knowledge employed in research and development, results are bound to emerge, and that the effectiveness of the work of technicians increases when they are employed in the larger organized works.

Dr. Haskins is no less conscious of the law of diminishing returns. The ultimate limiting factor is the inherent rarity of the real innovating mind. We must, he thinks, accept the fact that in any human population there will be only a small proportion of such minds. We are far from certain how small that proportion need be under the best conditions. Those conditions can eliminate waste and frustration though they cannot increase the absolute number, and it is to consideration of the nature of those conditions that Dr. Haskins devotes the later part of his report.

Although our contemporary culture affords opportunities for creativeness probably unrivalled in history, it also has hazards that may likewise be unequalled. One such hazard is inherent in the very structure of thought and philosophy which may crystallize about a field of inquiry, forming more powerful and dangerous barriers to the advance of concept and experiment alike than we ordinarily recognize. Prof. Carter and Prof. Williams concluded their report to the Science and Industry Committee with the observation that it would take much ingenuity by industry and Government to break up the crust of habit and to divert lively and able minds from the places where change is most likely to those where it is most needed ; and Prof. Jewkes comments specifically on the serious danger that institutions will tend with time to grow stiff in outline and rigid in outlook, and on the challenge which genius accordingly presents. He and his colleagues ask indeed whether, even though there now may be more people with the knowledge and training that may be a pre-requisite for invention, they are used in ways which make it less likely that they will invent. Is there truth in the idea that, although the institution is a powerful force in accumulating, preserving, disseminating and projecting, it will normally be weak in its power to originate and will, therefore, carry within itself the seeds of stagnation unless the powers and opportunities of individuals to compete with, resist, challenge, defy and, if necessary, overturn, the institutions can be preserved ? Or, in other words, is the growth of large-scale invention, of government-sponsored research or even of university education likely to reduce innovation by increasing resistance to change. In science, as in politics, the block mind can be a danger.

A. N. Whitehead's belief that the vitality of thought is in adventure is no less impressed on Dr. Haskins. The more elaborate the pattern of a system of thought, the more adequate, the more satisfactory and the more self-consistent it seems, the more difficult it is to transcend and the greater may be the resistance to truly original departures from it. This paradoxical balance between the older thinking and the new, he points out, is the more delicate because it seems inevitable that, although all new scientific concepts must transcend the older matrix from which they arise, if they are to become established and permanent they must also find firm links with it. This dual relation between the new advance and the older structure of knowledge and reasoning from which it springs may be largely responsible for the long interludes of refinement and consolidation, punctuated by shorter periods of explosive revolution, which characterize the history of human thought, and Dr. Haskins illustrates this thesis with examples from the sciences of life and mind.

There are, however, other more practical barriers. Pointing out that the modern world differs profoundly from other centuries in its conscious recognition of the fact—but not always the process—of innovation, he discounts the belief that because we can by organization accelerate the processes of development built upon innovation, we can also organize for greater innovation the creative act itself. Such misconceptions are peculiarly liable to occur in massive and highly organized environments devoted to research and development, and are inherent in the confusion between the processes of scientific research itself and of development, in the uncritical transfer of ideas and techniques from development and production into the field of scientific innovation. Among such misconceptions, too, is the destructive view that the effectiveness of innovation, like that of production, can be doubled simply by doubling the size of the accompanying effort.

Dr. Haskins thus returns to his deeply significant point that, in our own time of unparalleled technical advance, the great innovations are still highly individual, are still associated, at their inception, with a handful of names ; and that accordingly the comparative rarity of the environments most favourable to truly original investigation, their unusual and special character, and the frequent practical impediments to their best development, may impose sharper limitations on the creative potential of a nation than we are inclined to recognize. They provide, for example, a social basis for taking especial care, in the educational system, to encourage the gifted and exceptional individual. Again, climates of research must comprise many and varied elements, some of which are rarely joined in more ordinary situations. Incidentally, we know little as yet about the optimum size of a research group, or the way a group functions in developing new ideas, and the effect on a group and on himself in the group of an outstanding innovator.

Here the importance of understanding and protection is stressed. Since innovation is, and must, always remain a uniquely individual experience, it poses unusual social dangers for the investigator from which he must be adequately shielded—the animosity with which the new, with its threat to current things, must often provoke. Such dangers may not be fatal once the advance is fairly made; the greater risk is that the prospect of such hardships may inhibit the individual capable of great innovation from undertaking it or from fully developing its results. The unexampled richness of opportunity for scientific creativeness in our society enhances the need to analyse most carefully this climate in which true scientific originality best flourishes and to ensure that environments embodying it are adequately provided and conserved.

Dr. Haskins's prescription for institutions assuming these great responsibilities deserves widespread attention, not only from the universities, independent research institutions and professional associations, but also from the research councils and the Advisory Council on Scientific Policy. The most important of their tasks is, of course, the discovery, the encouragement and the adequate training of the outstandingly original investigator, and the fostering of his work. Such institutions must therefore be unusually sensitive to the rare, natively innovating mind, and unusually adept in its discovery. They must possess in high degree the ability to promote and develop the peculiar drive, the special verve and flair, the fine sense of style which great innovations inherently require, and be able to train the innovator of exceptional promise in the company of other gifted investigators already mature and at the height of their powers.

Above all, such institutions need to create unconventional and malleable environments, meeting not merely the different requirements of different workers, but also of the same investigator at various periods of his working life. Besides provision for the long periods of seclusion and introversion that may be essential during periods of highest creativity, Dr. Haskins insists on ample understanding and capacity to shield the worker in this his most vulnerable time from the insistent demands that will surely come to formulate results and conclusions prematurely. Such institutions must also be able to set and apply subtle standards of excellence, judging and rewarding high standards of excellence by more searching criteria than are often superficially accepted. They need teachers of research of the highest quality and in high ratio to those they train, and finally they have the supreme responsibility of communicating rapidly and effectively to workers in fields that may seem far remote, yet may actually be contiguous to those in which the discoveries have been made.

Ideally, Dr. Haskins believes that such institutions should be relatively small and certainly decentralized so far as possible, and in his view both the universities and the research institutions have a part to play. Neither, however, is likely to meet his prescription unless there is a greater awareness that the nation's reserves of men and women capable of advanced training are limited. The higher educational institutions must give much greater attention to this question of quality, and to making the best use of the exceptional individual. Lord James recently pointed out that we still have very little knowledge of the extent of resources in human capacity; but even while that knowledge is being acquired, we should be giving much greater attention to the needs of outstanding ability than is evident, for example, in the questions which Lord Simon put forward for inquiry in a recent issue of *The Universities Quarterly*. That should be a determining factor in considering, for example, the size of a university, the relations between research and teaching, and the size of a research school; and it accentuates the importance of academic autonomy.

Dr. Haskins notes some of the conditions which hinder universities, both in the United States and in Britain, in discharging their responsibilities in discovering and training new generations of investigators in science. In such an expansion as that which is now contemplated, the universities are particularly vulnerable to pressures which hinder the establishment or maintenance of the conditions which are most desirable for the outstanding innovator but which the community can ill afford to supply for the mediocre. To maintain high standards in teaching staff and high ratios of staff to students will not be easy; to supply appropriate conditions for a research school still less easy, even in the absence of any tendency to require an honours student to undertake research whether or not he has the ability or disposition for research or intends to follow such a career. Nor is the training of the exceptionally gifted individual or the great innovator the only responsibility of the universities.

All this points to the need for diversity, and Dr. Haskins is convinced as to the place the research institute can take in discovering and fostering new minds of high promise, of selecting them with discernment, of affording them full training as investigators, and then seeing that their careers can be spent where their talents are most effective. He has in this address directed attention to opportunities and dangers that exist in Britain as well as in the United States, to problems to which urgent attention is demanded both in planning the expansion of universities and colleges of technology and in considering the organization of the whole structure for research. That some of them have of late been disregarded is unhappily only too apparent; but his report presents a challenge which the Government and the universities must accept if Britain is to develop and use effectively its full resources in scientific and technical manpower.

ANATOMY OF A CŒLACANTH

Anatomie de *Latimeria chalumnae*

Par J. Millot et J. Anthony. Tome 1: Squelette, Muscles et Formations de soutien. Pp. i+122+80 planches. (Paris: Éditions du Centre National de la Recherche Scientifique, 1958.) 9,800 francs.

If we have had long to wait for the detailed account of the anatomy of *Latimeria*, at least the first instalment handsomely justifies the gestation-period. It is, moreover, the part which will be of greatest interest to palæontologists, who have so patiently and skilfully unravelled the structure of the long-extinct relatives of this anachronistic fish. There is an æsthetic pleasure in seeing how, in detail after detail, *Latimeria* takes its place in the evolutionary pattern already outlined by the study of the difficult fossil material. There are some surprises. The nature of the rostral organ and the lack of relationship between the endocranial cast and the shape of the brain have been dealt with in earlier papers, though it must be said that palæontologists have been cautious in their claims for such casts. The pectoral girdle was not well known in any fossil and it proves to have no skeletal connexion with the head. The urohyal has both endochondral and dermal components. Some arguments have been settled; for example, a cavity which in a fossil Stensiö interpreted as lodging the fixed end of the eye-muscles turns out to be occupied by cartilage, as Watson surmised, and the eye-muscles excavate no myodome.

The general structure of the head had been outlined in an earlier paper, but now a series of photographs of dissections and of sagittal, parasagittal and transverse sections, each with its explanatory diagram alongside, makes every detail clear. We see the structure of the intracranial hinge; the pair of apophyses of the anterior half sliding in long oblique grooves in the posterior half; and the pair of huge subcranial muscles bulging the lining of the roof of the bucco-pharynx. These last originate on the base of the prootic mass and are inserted by broad aponeuroses on the sides of the parasphenoid, and must restore the two parts of the cranium to the position in which the apophyses of the hinge lie at rest in their sockets at the tops of the grooves. They recall the forward extension of the hypaxial body-muscles of the teleost *Chauliodus* (Tchernavin, V. V., 1953, and Günther, K., and Deckert, K., 1955). In *Chauliodus* the hinge lies between the occiput and the modified anterior vertebral region and is, of course, not intracranial, but, as in *Latimeria*, it is at the anterior limit of the persistent notochord. In *Chauliodus* the whole neurocranium is moved down and up by the subcranial extension of the hypaxial muscles and their antagonists the epaxial muscles, which send aponeuroses forward on to the cranial roof and act in conjunction with the complicated apparatus which opens the mouth. Millot and Anthony have searched in vain for a simple antagonist to the subcranial muscles, for there is in *Latimeria* no dorsal extension of the epaxial muscle or its tendons on to the anterior cranial half. They find an indirect antagonist, however, in the coraco-mandibular muscle, which lowers the mandible and at the same time transmits its force through the palatoquadrate arch to push the front of the cranium upwards and forwards, so that the hinge-apophyses slide forwards and downwards in their grooves. From Fig. 20 and others it would seem that this might be reinforced by the upward push of the hind end of the lower jaw on the symplectic, which (as in *Amia*) articulates with it behind the quadrate, on which the mandible is pivoted. In advanced teleost fishes, where processes of the premaxillaries slide upon the ethmoid, the upper jaw moves forwards relative to the cranium instead of the fore-cranium to the hind-cranium. In this action the fibrous skin of the lip plays a part, and this may be so in *Latimeria*, too.

More than the functional analogies and contrasts, however, most vertebrate zoologists will look for the deployment of the basic vertebrate morphology in the sixth of the main vertebrate evolutionary lines which were already recognizable in the Devonian, and which survive to-day as Selachii, Holocephali, Actinopterygii, Dipnoi, Tetrapoda and *Latimeria*. A feast is spread for us in this field, of which no reviewer's sample can give an adequate idea.

Great interest is attached to the paired and median pediculate fins. Any hope that the paired fins might conform to the theoretical (and rhipidistian) precursor of the limbs of land vertebrates is soon dispelled. Not only is there nothing to compare with the radius and ulna (or tibia and fibula), but the pectoral girdle provides the apophysis, and the basal joint of the fin-lobe the socket, for the pectoral fin-joint, instead of vice versa as might have been expected. This is one of several features which underline the early separation of the cœlacanth stock from the rhipidistian.

The fin-rays, called lepidotrichia by the authors, are not exactly like actinopterygian lepidotrichia, being forked only at their bases and single for the greater part of their length (although one would like to see this confirmed by a transverse section). The dorsal and ventral lobes of the 'caudal fin' have radial supports and only the rays of the terminal lobe conform to the restricted definition of a caudal fin in articulating directly with the neural and hæmal arches, here much reduced and, of course, not broadened into hypurals.

Le Centre National de la Recherche Scientifique has given this book an unusual form worthy of its unusual subject. The volume is first opened in the middle and the pages of each half are hinged along the top, so that the reader can have a two-column page of text on the left, and on the right can turn to any plate with its accompanying explanatory diagram. The photographers, radiographer and draughtsmen have done a magnificent job and we have nothing but gratitude and admiration for the authors, both busy men whose normal occupations had to be continued while they explored this precious material and made themselves familiar with the literature in a field which was hitherto the speciality of neither of them.

The price will strain most private purses and may well make librarians blench, but buyers may be assured of good value and should then start saving for the next volume. E. Trewavas

CHEMISTRY IN SCHOOLS

The Teaching of Chemistry

By N. F. Newbury. Second edition, completely revised and reset. Pp. xv+294. (London: William Heinemann, Ltd., 1958.) 21*s*. net.

This book is designed to help the young chemistry master in his first appointment, and also to help teachers-in-training; it is a very practical book, full of detailed advice. The book is intended to cover the whole range of ages up to the university. The author, who is director of education of St. Helens, has clearly spent much time and effort in studying and collecting the views of many science masters and this book represents the fruit of his labours.

The first two chapters, it is true, represent an excursion into higher regions; but the rest of the book is very much down-to-earth. The third chapter suggests detailed syllabuses for elementary and advanced courses; the fourth gives a mass of advice to the new master, starting on his first appointment; the fifth discusses in great detail the practical organization of a school laboratory, the type of equipment required (including the scope of improvized and home-made apparatus), laboratory rules, and safety precautions; Chapter 6 discusses the roles of individual laboratory work by pupils and practical demonstrations by the teacher; Chapter 7 gives useful advice on teaching quantitative methods; Chapter 8 deals with small-scale methods, again with detailed instructions for improvizing equipment cheaply; Chapter 9 deals with the teaching of chemical theory, with special reference to the introduction of chemical formulæ; Chapter 10 discusses problems of scientific language and terminology and with teaching pupils to take notes; Chapter 11 deals with the use of diagrams and visual aids, including models, films, and useful advice on sources of educational films; Chapter 12 discusses the teaching of experimental technique; and the final chapters suggest ways in which chemistry courses can be adapted to local conditions, the role of school clubs and visits, and the organization of a school science library.

This is a very mixed book. It contains a great deal of useful information, set out in a disjointed and incoherent form, and one gets the impression that the author has relied more on the experience of others than his own. The chapters on practical work contain detailed accounts of apparatus and experiments, but very little on the kind of problems that actually arise in teaching practical chemistry. The theoretical syllabuses seem old-fashioned and unrealistic; for example, the author would defer any discussion of chemical formulæ and equations until half-way through the third year of the course.

In short, although this book would be useful to a critical reader, it could prove misleading to a young science master who had no other guide.

M. J. S. DEWAR

PHILOSOPHICAL PSYCHOLOGY

The Concept of Motivation

By Dr. R. S. Peters. (Studies in Philosophical Psychology.) Pp. viii + 166. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1958.) 14*s*. net.

DR. PETERS's book on motivation is the fourth volume to appear in the Routledge "Studies in Philosophical Psychology" which commenced publication in 1957. Dr. Peters describes his book as "a missionary enterprise", and it is designed to show psychologists that their theories of motivation are muddled, that any over-all theory of motivation is an impossibility, and indeed further that any attempt to construct a systematic and comprehensive science of psychology is not merely premature but also logically indefensible.

Let it be said at once that Dr. Peters is far more deserving of a sympathetic hearing than most philosophical critics of psychology, simply because he knows much more psychology than is usually the case. He has read the literature of psychology widely and acutely. His detailed criticisms of particular theories are worthy of attention, though he tends to take these theories much more seriously than psychologists themselves. Instead of regarding them as moves in a game, none of them as yet final, he takes them rather as *ex cathedra* pronouncements, and speaks of "the established order in psychology". There is, of course, no such thing as an established order in psychology, and no establishment among psychologists. Psychology is a branch of scientific inquiry, not an orthodox creed. In subtle ways like this Dr. Peters shows that in spite of his extensive knowledge he is in fact a touch-line observer and not himself a player.

The point over which psychologists will want to take issue, however, is not the detailed criticism of current theories, but the contention that the attempt to construct a systematic theory of motivation is in principle wrong. Here Dr. Peters is not likely to make many converts and his missionary enterprise is likely to fail. For one thing, criticisms of this kind are far from new. The gist of what Dr. Peters says was said many years ago by Socrates in answer to Anaxagoras (Plato, "Phaedo", 97*B*–99*D*). It has been repeated by philosophers, particularly those of an idealistic complexion, throughout the ages. It is unlikely that Dr. Peters will convince where his distinguished predecessors have failed to do so.

Basically the reason for this is that in starting point and in methodology Dr. Peters and the psychologist are far removed from each other. Dr. Peters believes that we "already know too much about human behaviour". His interest in human nature is moral and practical. If he can give an obvious practical answer to the question 'Why does Mr. *A* do *X* ?', Dr. Peters is satisfied and regards further explanation as 'otiose'. What Dr. Peters lacks is scientific curiosity, the desire to probe beneath the surface of the familiar and conventional. He does not see that in fact even everyday human actions are mysterious and remarkable performances. For it is, of course, wholly untrue that we know too much about human behaviour in any acceptable scientific sense. We know scarcely more than primitive pre-scientific man knew about the physical universe. It is this belief, which Dr. Peters shares with other philosophers, that human behaviour is, as Ryle put it, "relatively easy to understand", which places a wide gulf between the philosophic critic and the psychologist.

Secondly, in his method of approach Dr. Peters is fundamentally verbal. What is needed in psychology, he maintains, is conceptual analysis rather than research (p. 141). He is all the time concerned with "sorts of question" and "linguistic usages"; he is not really interested in the functioning of behaviour as such. One constantly feels the spiritual gulf between this method of approach and that of the psychologist, the difference between a concern for words and a concern for matters of fact.

Finally, there is Dr. Peters's own brand of dogmatism, his unhesitating assumption that nature and 'convention' belong to two different realms, and that because human behaviour is essentially 'conventional' (that is to say, conforming to social standards and rules) it cannot be explained in the language of natural science. But the assumption that nature and convention can never be embraced in a unitary explanatory scheme is a gratuitous one, and by no means logically necessary as Dr. Peters claims. All that can be said is that certain kinds of scientific explanation are incompatible with goal-seeking and rule-following. Science, however, is not, as Dr. Peters seems to suppose, tied down to any particular form of explanatory model. Perhaps more promising than either the dogmatic dualism to which Dr. Peters himself adheres, or the mechanical monism which he criticizes, is an emergence theory which allows for the development of novel organizational levels, but sees these as fundamentally rooted in a common natural world. L. S. HEARNSHAW

PROGRESS IN VITAMIN AND HORMONE RESEARCH

Vitamins and Hormones

Advances in Research and Applications, Vol. 15. Edited by Prof. Robert S. Harris, Prof. G. F. Marrian and Prof. Kenneth V. Thimann. Pp. xi+355. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 9.50 dollars.

IT might have been expected that vitamins and hormones could not remain easy bed-fellows indefinitely, but for fifteen annual volumes there has been no sign of discord. It is perhaps natural that vitamins or nutritional problems often take precedence over hormonal ones in these annual volumes, but in the one under review an equal distribution of articles between the two fields of study has been achieved. Three of the articles are on vitamins and related substances, three are on hormones, one is concerned with both vitamins and hormones, and the remaining one, on the biosynthesis of cholesterol, is relevant to both fields of study in so far as cholesterol is a precursor both of steroid hormones and of vitamins D.

The first article, by A. W. Johnson and Sir Alexander Todd on the "Chemistry of Vitamin B_{12}", includes not only an account of the research on the isolation, structure, and chemical and physical properties of the vitamin and of substances related to it, but also a discussion of the biosynthesis of vitamin B_{12} and related substances and the chemical determination thereof. "Total Syntheses of Carotenoids" are discussed by O. Isler and P. Zeller in an article which is a masterly chemical condensation. The metabolic importance of carnitine, a subject reviewed by G. Fraenkel and S. Friedman, which since 1952 has been recognized as an insect growth factor, is still not clear, but the relevant information is ably surveyed. In "The Biological Synthesis of Cholesterol", Konrad Bloch considers a subject to which he himself has made most important contributions and which now lends itself to a chemically co-ordinated treatment which is largely based on research of the past ten years. With "Adrenaline and Noradrenaline", J. H. Gaddum and M. Holzbauer deal with a subject in which interest is rapidly growing in many respects, not least with regard to the possible effects of the central nervous system, but the article concerns itself largely with the better known experimental work on this most interesting pair of substances. R. C. de Bodo and N. Altszuler consider "The Metabolic Effects of Growth Hormone and Their Physiological Significance", while "Steroids in Human Blood" (R. Borth) deals with methods and with the interpretation of results in an orderly fashion. Finally, in surveying the "Influence of Hormones, Vitamins, and Other Dietary Factors upon the Formation of Bone, Dentine, and Enamel", J. T. Irving has brought together much information that would not be easily obtained otherwise within the covers of a single article.

The editors aim at making this publication international in its authorship and authoritative in its statements. In this volume they have clearly achieved both these aims. F. G. YOUNG

J. L. W. THUDICHUM

Thudichum

Chemist of the Brain. By Prof. David L. Drabkin. Pp. 309. (Philadelphia, Pa.: University of Pennsylvania Press; London: Oxford University Press, 1958.) 40s. net.

THUDICHUM, born in 1829 in Büdingen in the Grand Duchy of Hesse, studied medicine in Giessen, where he came under the influence of Liebig. Soon after graduating, he emigrated to London, probably for political reasons, and built up a successful medical practice. He was a very remarkable man of wide scientific and artistic interests and was possessed of an unfailing energy. He wrote on many medical and other subjects, ranging from books on the pathology of urine, the treatment of nasal polypi, and the origin, nature and variety of wine, to his master work, unacknowledged during his life-time, on the chemical constitution of the brain.

Prof. D. L. Drabkin's interest in Thudichum dates from 1924 when he worked on the urinary pigment urochrome, first so named by Thudichum. In the following thirty years he collected probably all the information available about Thudichum; thus, when invited to give four lectures on Thudichum in 1954, he set himself the task of finding the reasons for the lack of recognition of a man who is now generally acclaimed as one of the pioneers in the field of brain chemistry. The answer is not a simple one. The circumstances in which Thudichum carried out the greater part of his work, in a laboratory in his home, were highly unorthodox. The expenses were met from Government grants and later from the income of his lucrative practice. The results he obtained differed in important aspects from those of his contemporaries and he became involved in polemics which were violent even by nineteenth century standards, thus making powerful enemies. His versatility and large literary output led to the quite unjust charge of dilettantism and, what was worse, the integrity of his work was doubted. This and other evidence convinced Prof. Drabkin of the existence of a conspiracy against Thudichum.

The three main chapters of the book: the man, his times and contemporaries, and his works, make interesting reading although the rather expansive style and the inclusion of not strictly relevant material may not be to everyone's liking. The book, besides being liberally illustrated with 'Thudichumiana', is well documented with references, biographical details, a bibliography, transcriptions of letters, etc. (82 pages). Thus it gives a good deal of information for students of the early history of biochemistry and also contributes to the difficult problem of what constitutes a climate of opinion sufficiently receptive to give recognition to the work of a pioneer.

H. W. KOSTERLITZ

FUSION OF HEAVY HYDROGEN*

By Dr. T. E. ALLIBONE, F.R.S.

Associated Electrical Industries, Ltd., Aldermaston

'GENEVA' has come and gone, leaving in its trail a huge mass of printed papers that will keep scientists occupied for a long time to come. The research on fusion of deuterium has been secret for eight years; but now we can see the whole vista of thermonuclear research in many countries as revealed at Geneva in 1958, and in a short space I will try to present this vast subject as it might be seen if looked at down the wrong end of a telescope. The subject will not be dealt with chronologically, nor can all the investigators be mentioned by name in the space available.

All we are trying to do is to heat deuterium or heavy hydrogen to a temperature of many million degrees and keep it at this temperature; if one can do this the nuclei will, from time to time, coalesce or fuse together in several different ways, each reaction liberating much energy. Thus, two deuterium nuclei can form tritium and a proton; or can form helium-3 and a neutron. The tritium, fusing with deuterium, can form helium-4 and a neutron; the helium-3 and deuterium can form helium-4 and a proton. In all these reactions the released energy will be given to the two particles formed in the discharge, which will, in consequence, repel one another with high velocity. In total, as much energy would be released by the *fusion* of 1 gm. of hydrogen as would be released by the *fission* of 3·5 gm. of uranium, and by the burning of 10 tons of coal. In such a fusion reaction 40 per cent of all the energy released is given to neutrons and they would almost certainly escape from any vessel containing the hot gas; 60 per cent is given to the charged particles which might, or might not, escape according to the circumstances of the experiment.

The deuterium – tritium reaction proceeds at a lower temperature than the deuterium – deuterium reaction, but, though there is plenty of deuterium in the ocean, tritium does not exist in Nature, and is made in an atomic fission reactor. Actually, the neutrons escaping from a deuterium – deuterium or deuterium – tritium reaction could be absorbed in a blanket of beryllium, which dissociates to yield two neutrons for every neutron absorbed, and these in turn could be absorbed in lithium, which then dissociates to tritium, so there is a chance of breeding more tritium than is consumed in the fusion reaction. In the long run, therefore, the fusion reactor of the future may operate on the deuterium – tritium reaction.

A hot gas, like any other hot body, can lose heat by radiation, by conduction, and by convection; so the achievement of a given temperature is set by the balance between the rate of loss of energy by these three processes and the rate of gain of energy, either from an external source or from the release of nuclear energy when the deuterium atoms fuse together. Fortunately, the rate of release of energy by fusion rises extremely rapidly with temperature; for example, if the temperature is increased from 10^6 to 10^7 degrees the rate of fusion increases by 10^8, and a further rise of temperature to 10^8 degrees increases the rise of fusion by a further 10^4, whereas the energy radiated by the gas only increases as the square root of the temperature. This is indeed fortunate, because there is nothing we can do to stop energy being radiated from the gas. The other losses, convection and conduction, would occur if the hot gas actually came in contact with the walls of the containing vessel; but it is generally assumed that this must be prevented at all costs, since the gas temperature is so very high compared with the melting points of all metals that if the hot gas bombarded the walls anywhere the walls would evaporate, and would introduce impurities into the gas. These impurities cannot be tolerated, for their presence in the gas would immediately lead to a rapid increase in the amount of heat radiated. It has been calculated that the break-even temperature of the reaction, that is, where the total energy released by fusion just exceeds the total energy fed into the discharge, is about a hundred million degrees, which is a few times hotter than the centre of the Sun and many thousand times hotter than the surface of the Sun.

At these temperatures the atoms are colliding with one another with such high speed that all the electrons are knocked off the light elements. In the case of hydrogen (or deuterium) all atoms will be dissociated, there will be as many electrons as there are hydrogen nuclei and we call this mixture a plasma. It is electrically neutral, being made up of an equal number of opposite charges. If the plasma is in a magnetic field the charged particles can move freely down a magnetic line of force; but if they have any component of velocity perpendicular to the magnetic field they will describe circles around the lines of force, or spirals if they are drifting down the line. Positive nuclei having a larger mass than electrons will describe larger orbits than electrons having the same energy.

The method used by nearly all investigators to keep the hot gas from touching the walls of the vessel depends on the force exerted by the self-magnetic field of a current, and this force will cause the current to pinch away from the walls of the vessel until the inward force is balanced by the outward pressure of the gas. The first recorded photograph of a discharge pinched due to its own magnetic field is due to Ware and Cousins. A current of many thousands of amperes was discharged through a gas in a toroidal vessel, and in a few microseconds the discharge had pinched to a small diameter, and having contracted beyond its equilibrium it 'bounced' out again and contracted and expanded several times, thus exhibiting a form of instability. When the current was maintained for some hundreds of microseconds, the discharge already pinched to a narrow diameter moved rapidly about in the discharge vessel—we speak of this as 'wriggling'—striking the walls, and with currents of 10^5 amperes severe volatilization of the metal walls of a large torus vessel occurred.

The explanation of these instabilities is not hard to follow in general terms; in the case of 'pinch instability' any geometrical irregularity of the vessel can cause a slightly higher localized self-magnetic field which, acting on the current in the discharge, will compress the gas more than elsewhere, and so a localized pinch will develop; in the case of 'wriggle instability' any slight departure from a perfectly linear discharge will cause a bunching of the lines of force on the inner radius of any small bulge so formed and force the discharge to bulge farther off the axis.

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* Substance of a Friday Evening Discourse delivered at the Royal Institution on December 12.

A few years ago investigators in several laboratories detected bursts of neutrons emitted for fractions of a μsec. and naturally suspected that they had achieved very high temperatures; but all of them ultimately found that the neutrons arose from the collisions of a few deuterium ions endowed with far more energy than the mean energy of the gas, and proved that the very act of over-pinching at localized points created high local electric fields across which a few ions were accelerated to high energy and that these fast ions were responsible for the deuterium–deuterium reactions.

Theory indicated that if a constant magnetic field were set up in the discharge vessel parallel to the axis of the discharge then the lines of force of this field would, in a sense, stiffen the discharge and prevent in some circumstances both the pinch instability and the wriggle instability. A succession of photographs, each lasting a half μsec., were taken of a discharge in a cylindrical vessel, the records being made every half μsec. In the absence of an applied axial magnetic field the discharge was observed to pinch rapidly, but in 4 μsec. it became unstable and lashed about in the vessel. As the value of the magnetic field was increased, the rate of contraction of the pinch was reduced; but the onset of wriggle instability was postponed. Without the field neutrons were observed at the moments of minimum contraction, but as the field was increased the number of neutrons detected diminished. Presumably the spurious accelerating mechanisms which previously produced neutrons do not operate in a relatively stable gas column.

Straight discharge tubes will ultimately suffer from the fact that they must have electrodes at each end, and therefore after some μsec. of operation the gas discharge will heat these electrodes and evaporate them to some degree and so introduce impurity atoms into the gas. Nevertheless, many investigators in several countries are still building new apparatus having this simple cylindrical geometry, in order to study further how to stabilize a discharge to keep it from striking the walls. In one case, in order to minimize end effects, a new tube has been made 20 ft. in length, 6 in. in diameter, and in this a new peculiar form of large-amplitude rotational instability has recently been found. In another recently constructed straight tube the discharge is in the form of a hollow cylinder between annular electrodes at each end of the tube, but the return current passes up both an inner and an outer copper cylinder (hence the name *Triax* for this tube). The return currents flowing in each metal cylinder produce two oppositely directed magnetic fields, in the space between which the gas is squeezed into a thin sheath which has most remarkably stable properties.

In Britain twelve years ago, when this kind of work was begun, the avoidance of end-electrode effects was regarded as imperative, so almost the whole of the development in Britain has centred on toroidal geometry. In early records of the discharge in glass toroidal vessels which we operated in Aldermaston, the discharge was photographed with exposures of 1 μsec. duration at various times up to 400 μsec. after initiation of the discharge. For many μsec. the discharge is pinched to a relatively stable narrow toroidal beam and then the sideways wriggles develop over the following few hundred μsec. If a solenoidal winding is placed around the torus and current passed through it to create a strong field down the axis of the vessel, then the discharge is rendered much more stable by the field of the solenoid. It pinches away from the walls of the tube as the current rises in the gas and occupies the central region of the vessel for relatively long periods of time. When the discharge tube is very clean, the amount of light from the discharge is feeble; but it is possible to take photographic records of the very highly ionized atoms of oxygen which are always present there as an impurity, oxygen atoms which have been stripped of four of their eight electrons. The distribution of the light intensity in spectrum lines of quadruply ionized oxygen atoms has been determined over the diameter of the torus, taking such records at different times from the beginning of the discharge, and it is found that the highly ionized oxygen atoms remain reasonably well centred on the axis of one of the torus tubes constructed in Aldermaston (*Sceptre III*) for 600 μsec.

Neutrons have been produced in the past year in several toroidal vessels, in *Zeta* at Harwell and *Sceptre* at Aldermaston in England, in the apparatus called *Perhapsatron* at Los Alamos, and in the copy of our apparatus built by the Russians in 1958. The first point of interest to note is that the durations of reasonably stable discharges in toroidal vessels have been far longer than in linear vessels, lasting up to, for example, several milliseconds, and neutrons are emitted through a large fraction of the whole current pulse. It is very natural to think, therefore, that as the violent motions of the discharge have been prevented by the externally applied magnetic field the temperature of the gas might have risen to a high enough value for a true thermonuclear reaction to have occurred. We can get some idea of the temperature of the gas by examining one of the spectrum lines of highly ionized impurity oxygen gas in a high-resolution spectrograph and comparing it with a normal spectrum line of nearly the same wave-length emitted by some atoms. The oxygen line is found to be far broader, signifying that the atoms of oxygen in the vessel are approaching or receding from the recording apparatus with high velocity—so-called 'Doppler broadening' of the spectrum line; from this an estimate of the temperature of the gas can be made. This comes out at several million degrees, and at this temperature we might expect a large number of deuterium collisions yielding neutrons and protons. If the gas is all at this temperature the neutrons and protons will be emitted equally in all directions and will have an energy of 3 MeV.; if, however, most of the gas is at a lower temperature but a few of the deuterium ions have, for some reason or other, a high velocity in the general direction of the discharge, then neutrons and protons emitted from fusion of these fast ions will travel faster in the forward direction of the discharge than in the reverse direction. In Aldermaston we looked for protons coming out of the tube in two directions, at 30° and at 150°, to the direction of the positive-ion gas current. Those coming out in the forward direction were found to have slightly more energy than those coming out in the reverse direction, indicating that the centre of mass of the deuterium–deuterium ions which collide to yield the protons is moving in the direction of the ion current with a speed well in excess of the mean velocity. It therefore looks as though the ion velocities are not truly randomized but that a few are going faster than expected, and therefore the reaction cannot be described as truly 'thermonuclear'. All investigators working on toroidal discharges reported agreement on this point at Geneva. The really surprising feature of the measurements is that the temperature is as low as it is, for the amount of energy being fed into the discharge from the condensers is far higher than is necessary merely to heat the gas to a few million degrees, and we are seeking to explain how some of the energy is being lost.

An entirely new concept for the containment of a gas at a temperature of millions of degrees is offered to us by scientists at the Livermore Laboratory, in California, the so-called 'mirror machine' principle. It will be recalled that a charged particle having a given velocity can travel along a magnetic field relatively easily but cannot travel across such a field in normal circumstances. If two strong magnetic fields are imposed locally at the ends of a straight discharge tube, the lines of force here are crowded together, and positive and negative ions travelling along the lines of force between the strong fields are trapped as though in the neck of a bottle and cannot easily escape, most of them being turned back on themselves; it must be noted, however, that ions travelling exactly on the axis, and indeed just at a small angle to the axis, can escape from the ends of the 'bottle'. As the strength of the mirror magnetic field is increased so the ions are turned back at an earlier stage and thus are confined to a smaller volume.

One difficult problem with mirror machines is associated with the injection of charged particles into the magnetic bottle; any particle injected through the end of the bottle on the axis will be turned around by the field at the far end of the bottle and emerge the same way that it went in. To avoid this emergence, it is necessary to change the magnetic field while the ion is still inside the bottle, that is to say, ions can be shot in and kept in only when the field is actually being increased; and as the field is increased they will be compressed into a smaller volume. Another way is to inject the beam from a source already inside the magnetic bottle, but again, if the field does not change after injection, the beam, in due course, after a number of rotations around the vessel, will strike the source; this too can be avoided, however, if the field is increased after injection of the ions. A very attractive feature of internal injection is that the beam can be initially injected with very high ion energy corresponding to a temperature of thousands of millions of degrees. This energy it shares with other ions in the chamber, and the main role of magnetic compression becomes one of containing the ions, not of increasing their temperature.

In the early research at Livermore on magnetic mirrors four years ago, it was found that shock waves could be generated in the gas by applying a magnetic field which rose extremely rapidly to high values. Very recently, a group working in Los Alamos has extended this work and has produced extremely high temperatures by shock heating. When currents are suddenly passed through two adjacent short solenoids mounted on the same axis, large currents are induced in the gas flowing in the opposite direction. The current in the coil repels the current in the gas, thus driving the ionized gas to the axis of the coil, and two shock waves are generated which will meet one another between the coils, giving a region of maximum compression. If, in addition, the magnetic field in each coil continues to rise, the gas between them will be further compressed. In the most recent work at Los Alamos the shock compression of the gas occurs within 0·2 μsec. and maximum compression of the gas between the mirrors is reached in 1·5 μsec. Neutrons have been emitted at the peak of the compression, so that it is thought that in this very short time the temperature of deuterium has been uniformly raised high enough to yield a true thermonuclear reaction. However, more work will be necessary to establish that this is so.

In everything described so far, the duration of the experiment has been very short, from a μsec. or two for the shock excitation, hundreds of μsec. for the mirror compression machine, and a few msec. for the largest of the toroidal discharges, and it is not easy to see how such experiments could lead to useful thermonuclear power reactors. They are essentially steps along the way. One or two very recent developments have been described which might in the long run become the prototype of nuclear fusion power-producing reactors, because if successful they might be able to operate continuously. The first of these was developed at Oak Ridge in America, called the *D.C.X.* machine, and we learned at Geneva that the Russians had developed a slightly different version of this known as *Ogra*.

Scientists in Oak Ridge have tackled the problem of supplying energy to the plasma of deuterium ions and electrons in a radial fashion. Instead of developing a transient magnetic field rising rapidly to compress and heat the ions, or, as in the Livermore mirror machines, to contain energetic ions injected into the machine at low magnetic field strengths, they believe that a steady-state device can be made to hold the plasma while energy is fed in electrically from outside. A 'magnetic bottle' of high intensity is set up in a cylindrical chamber to prevent any ions from escaping at its ends. Then into the chamber, at right angles to the lines of magnetic force, is directed a beam of singly charged molecules of deuterium accelerated to about 600,000 volts in a discharge tube. These ions have so much energy that there is no need to give them more by magnetic compression when inside the bottle. They are deflected by the magnetic field into a circular orbit; but after a short distance the beam is fired across a carbon arc extending along the lines of magnetic force between two electrodes. As the deuterium molecule goes through the arc there is a very high probability that it will be split up into a deuterium nucleus and a neutral atom of deuterium. The latter, being neutral, escapes; the deuterium nucleus, however, is deflected into circular orbit of smaller radius by the magnetic field, and continues to rotate in this orbit wholly within the vessel, ionizing residual gas by colliding with deuterium nuclei, the temperature of which is thus raised. If this process continued long enough and if losses could be kept down, then the temperature of the whole of the deuterium in the bottle would slowly rise until nuclear fusion begins.

Russian scientists described the apparatus known as *Ogra* at Geneva—it seems to be a copy of *D.C.X.*—but they had not fallen upon the rather nice idea of using a carbon arc to dissociate the deuterium molecular ion. Instead, in this apparatus the molecule must be dissociated by chance collisions with deuterium atoms and, in consequence of this, the apparatus has to be much longer than the American *D.C.X.* machine to guarantee that the deuterium molecule is dissociated and does not escape.

The American and Russian devices have not been working very long, and there are some obvious difficulties, the most important of which is a large loss of beam by what is known as the 'charge exchange mechanism'. If the energetic deuterium ion collides with a neutral atom of gas and picks up an electron from it, thus becoming a neutral atom itself, it will no longer be confined by the magnetic field and it will carry out of the apparatus much of the energy with which it was originally endowed. To reduce this, the pressure in the vacuum chamber must be as low as possible, and the current in the positive ion beam must be as high as possible to make good whatever loss there is. Nevertheless, particles have been trapped by the magnetic field and held in the vessel for many msec., and there are great expectations that high temperatures will soon be reached in the gas.

The second development which might become very important as a power producer also comes from America, the work of Prof. L. Spitzer and his team at Princeton, called the *Stellarator*. Several versions of this have been built in the past seven years, and at Geneva the plans for a very large version due to be completed in 1960 were described. Prof. Spitzer's goal from the first has been to confine the plasma for a very long time. Clearly a straight tube is no good for this purpose because of end-effects already described. Even if we turn a straight tube into a torus and attempt to confine the plasma by a magnetic field around the torus we shall lose particles in the long run for a very important reason: the positive and negative ions will drift apart in opposite directions across a cross-section of the torus. This arises because the field of a solenoid wound on a torus is stronger on the inner side of the torus than on the outer, so an ion is deflected through a smaller radius in the region of higher field than in the weaker part of the field. If it is travelling down the torus its orbit is not, therefore, a closed spiral, but a slowly drifting spiral, drifting upwards for positive charges; downwards for negative charges. Prof. Spitzer was able to correct this by twisting the torus into a figure of eight so that ions having drifted apart on one side drift back again on the other. Temperatures of a million degrees have been reached with the beam well confined for a long time by the *Stellarator* field. In later versions of this apparatus the twisting of the torus has been eliminated by applying a further set of windings over the torus to produce cusped fields which have the effect of cancelling out the drift motions of the ions.

To reach higher temperatures a system of magnetic pumping has been developed at Princeton; it consists of a localized pulsating magnetic field driven at radio-frequency, compressing and expanding the plasma locally as the plasma is driven by an electric field through the pump. Such an alternate compression and expansion would produce no net gain of heat in the gas if it were not for a phase-lag which occurs between the increase in density of the gas and the increase of temperature. A full theory of this complex problem has been developed to determine the correct frequency at which to pump; but experiments have not yet verified this theory.

The final point of importance to make about the *Stellarator* is that it incorporates a neat way of removing impurities from the vessel; this is probably essential if the gas is to reach very high temperatures. The device consists of a localized magnetic field of complex shape which strongly influences the lines of force at the edge of the torus, bending them outwards, but does not influence those in the central region. Heavy impurity ions leaving the walls of the vessel will, on the first time around the torus, be deflected and trapped in this 'diverter' field; whereas the hydrogen ions and electrons in the central regions of the torus will be uninfluenced and will not be lost to the diverter.

Finally, there is yet another device which shows great ingenuity and promise, the so-called 'homopolar plasma accelerator'. In this a magnetic field is directed parallel to the axis of a flat annular plate of ionized gas and is shaped to give mirror geometry to keep the plasma from escaping out of the annular space at the 'edge' of the plate. Between a cylindrical electrode on the inside of the annular plate and a cylindrical electrode on the outside of the plate is established an electrical field which, in the absence of the magnetic field, would cause current to flow radially outwards through the plate from cylinder to cylinder. But because of the magnetic field the plasma is forced to move at right angles to the electric and magnetic field; the plate therefore rotates like a flywheel about the central axis of the device, and the energy given to the flywheel ultimately appears as heat in the gas due to turbulent mixing within the flywheel. Containment times have been very satisfactory and fairly high temperatures have been recorded, but the device is a very recent development and much remains to be learnt about the physics of such rotating plasmas.

I seem to have listed a great many approaches to the same ultimate goal. Now that the cloak of secrecy has been removed, we see that in the United States and the U.S.S.R. a far greater effort has been put into this problem than in Great Britain. We know that in neither of those countries is there a shortage of fuel, nor need for speed of development of a fusion reactor—nor is there real justification for speed in Britain in the same sense that the fission development had to proceed to help solve our fuel problem. In Britain we have pursued almost only the toroidal approach. This does not necessarily mean that we have backed a 'wrong horse'; we have only backed one horse. The Russian scientist, Artsimovich, summed up the situation as he sees it in the U.S.S.R., where many different kinds of experiments are in progress: "So far not a single one of the ideas regarding controlled fusion reaction is decisively superior to any other, and therefore investigations in the near future must be carried out in many diverse directions".

Edward Teller's opinion is that it will be several more years before a machine can be constructed that produces more energy than it actually consumes. I should say it will be a year or two at least before we even see how to construct such a machine, knowing that it will work when constructed, for we have not yet reached containment for times long enough, nor have we devised systems which keep clean long enough, nor do we yet understand the way by which some of the energy is lost. In fact, at this moment we really have no justification for believing that the ultimate problem will be solved; it might be that we shall never achieve satisfactory containment; it might be that the radiated power will be of such surface density that evaporation of impurities from the walls will beat us; it might be that the reaction will have such a positive temperature coefficient that it will go off with explosive violence; all we can say at present is that we now have a fair measure of the difficulties, and with incurable optimism we believe we should spend money on the research because we have an inner conviction of success which will come in time.

Edward Teller and Artsimovich also mentioned the use of thermonuclear explosions to achieve peaceful objectives, such as rock crushing, mining, and huge earth-moving jobs. The fuel is extremely cheap compared with conventional fuel, and radioactive contamination from the thermonuclear explosion is small. It is the smallness of radioactive contamination that makes the fusion reaction so attractive compared with the fission reaction, as the ultimate source of power for the world.

PROPULSION BY IONS AND IONIZED PLASMAS

By Dr. A. von ENGEL

Visiting Professor of Physics, University of Oklahoma, Norman, Oklahoma

RECENTLY a concerted effort has been made in the United States to look for new types of fuel for the propulsion of rockets and space vehicles of various kinds. From papers given at a conference at the University of Maryland in October 1958, held under the auspices of the U.S.A.F. Air Research and Development Command, and from other communications, it appears now feasible to use other than the usual sources of chemical energy (combustion). More powerful fuels include free radicals, ions and plasmas. More than a hundred research projects are directly or indirectly connected with a study of this problem. Most of the work is done in universities, industrial and research corporations in the United States, some in Great Britain and in Germany. The results can be applied to military purposes, to pure research and to transport of mail and goods. Besides inter-continental postal service, it is thought to be of interest for the supply of the future space platforms.

As to the unorthodox type of chemical fuels, free radicals and atoms or molecules in a higher state of electronic excitation and dissociated molecular gases are being explored. The difficulty to be overcome is to obtain sufficiently large concentrations and amounts of the substances, and to prevent a release of their potential energy by reaction with the walls of the container, or corrosion during storage. Though some progress has been made, for example, in reducing the rate of association of atoms by freezing them into a solid matrix[1], it is not possible yet to make practical use of dissociated gases for propulsion.

An important parameter in rocket design is the thrust, f, per unit terrestrial weight of fuel expended in unit time, W, called the specific impulse I_s (in sec.). Numerical considerations show that I_s is lowest in the case of propulsion by an effluent compressed gas. For a gas of molecular weight M escaping through a nozzle with the velocity v, we have $I_s = f/W = (RT/M)/(gv)$. For air at room temperature flowing with molecular velocity, I_s is less than or equal to 100 sec. The conventional chemical reactions give values of I_s larger by about a factor 4 or so.

To obtain a large thrust acting on vehicles travelling with constant speed, both the rate of fuel expended and the exhaust velocity must be large. Thus positive ions have been suggested as fuels, since it is relatively easy to accelerate them to a speed of $v_i = 10^6$ cm./sec. and more. Here $I_s = v_i/g$ and is of the order 10^3–10^4 sec. For thrusts of 10^9 dynes, dm/dt becomes 10^3 gm./sec., and with heavy ions this would correspond to emission currents of 10^6 amp., which is beyond practical limits even during short periods. However, for controlled space vehicles 100–1,000 amp. lasting several years would be sufficient. The corresponding small thrusts would be convenient in navigation[2] ('astronautical attitude control'). Currents of that order could conceivably be drawn from cæsium–tungsten, or cæsium–tantalum, where cæsium atoms diffuse through the porous metal kept at about 1,100° K. into a vacuum. The cæsium atoms are thereby ionized, because the work function of tungsten or tantalum is larger than the ionization potential of cæsium. Present experiments give currents much less than the values quoted above. The size of the pores must be chosen so as to prevent unnecessary evaporation of neutral cæsium atoms. Erosion of the cathode by the fast cæsium ions can be reduced by careful design of the geometry of the electrode. In order to avoid electrostatic drag, the ion exhaust charge is to be neutralized by feeding electrons into it. Other sources of ions use hydrogen ions emitted from a heated palladium foil through which hydrogen is passed, and alkali ions by electrolysis through glass membranes[2].

Another means of propelling vehicles is to apply a mechanical pulse to the body to be driven by passing a current pulse through it while a magnetic field perpendicular to the current is established by the same current or separately. This is the principle of the electromagnetic gun, one of the ever-recurring war-time inventions. The limitations are obvious: a 50-gm. bullet of ½ cm. diameter fired with an initial velocity of 10^4 cm./sec. would require a charge of 10^3 coulombs in a field of 10^4 gauss. However, though the chances of success are slim, an investigation has been made of an accelerator firing projectiles of several hundred grams at 10^6 cm./sec. The accelerator is 10 m. long and has a single-layer winding along which slides a closely-fitting metal projectile. By means of precision switching, one turn of the winding after the other is made to carry the current; the switching is so timed that the electromagnetic impulse travels with the same speed as the projectile[3].

Instead of the metal projectile, a highly ionized gas may be used to obtain higher velocities, and several solutions have been envisaged which should give specific impulses of I_s equal to or greater than 10^3 sec. One method is to generate an arc discharge plasma in the form of a closed ring co-axial with a helical delay line. The plasma is accelerated by the radial component of the magnetic field of the helix while the arc current is maintained by the electromotive force caused by the difference between the velocity of propagation of the current in the helix and that of the arc plasma[4]. Another arrangement uses a number of discontinuous arc discharges in a uniform stationary magnetic field, whereby the plasma flames are led through an exhaust tube into the space[5].

An experimental study has been reported[6] recently which is another version of the shock tube[7], where the plasma itself represents the accelerated mass. An electromagnetically controlled valve admits a small amount of gas to an evacuated system. The gas is first feebly and afterwards fully ionized by a rapidly varying magnetic field. The plasma of the ring discharge formed is at the same time compressed radially and the shock wave so produced enters a tube inserted in a solenoid which is loaded with capacitors. This delay line acts as a magnetic piston which drives the plasma through the tube. The linear momentum of the plasma has been measured both by a capacitor microphone and a ballistic pendulum. Plasma speeds of 5×10^6 cm./sec. equal to the speed of the magnetic piston have been recorded with deuterium, and impulses of 80 gm. cm./sec. observed for single pulses. About one-fifth of the impulse is due to the neutral gas admitted.

A large number of investigations deal with the production and application of electric plasmas.

Exploding metal wires at low gas pressure have been studied[8], and with ion densities of about 10^{16}/cm.^{3} and current densities of 10^4 amp./cm.^{2} plasma accelerations up to 10^{13} cm./sec.^{2} are found. Plasma jets in helium using continuous electric arcs produce electrode and wall erosion which prevent their use when higher impulses are needed. These difficulties can be circumvented by using high-frequency electrodeless discharges induced by discharging a capacitor through a coil. The shock wave which ensues can be guided along the centre of the tube by axially symmetrical magnetic fields[9].

The design of electrodes and nozzles for the injection of the hot ionized plasma jet has been studied extensively. Such heads seem to work theoretically at pressures of 2,000 lb./sq. in. and power densities at the throat of the nozzle[10] of 5,000 kW./cm.^{2}.

Another problem which seems to be important in connexion with the plasma jet is the electric breakdown in a turbulent moving gas with the associated gas pressure and density gradients. Studies using Kerr cells in the millimicrosecond range and photographic measurements with a high-speed rotating mirror camera are being carried out[11].

Theoretical work is also being done to test whether the concept of magnetic pressure can be applied to all magnetohydrodynamic problems[12].

Plasma studies for propulsion and other applications may benefit from the work with transient magnetic fields[13] in the range 10^5–10^6 gauss. Coils with force-free windings have been operated which can stand the mechanical force components resulting from a slight unbalance, and it appears that this new tool may have a profound effect on atomic and nuclear research.

Studies of charge neutralization in plasmas have been made which show that the high values of recombination coefficients for electrons and positive molecular helium ions reported earlier (10^{-7}–10^{-8} cm.^{3}/sec.) seem to be erroneous. The neutralization processes have to be interpreted by including the formation of excited particles[14].

Measurements of the velocity of high-current arc flames in the pressure-range 760–20 mm. mercury have been carried out using carbon electrodes. The interaction of the tail flame with the magnetic field is already apparent in moderate fields. Since it depends upon the field gradient rather than the field, it is concluded that the electric dipole distribution in the flame is the cause of the interaction forces[15].

At low gas temperature, electric direct current or high-frequency discharges at various pressures in air have been used to produce supersonic jet exhaustion into a chamber kept at low pressure[16]. Measurements of the ion concentration as a function of the input energy show that about half the energy is used to dissociate the gas. Shock-free streams were obtained and it is hoped to increase the speeds up to Mach number 5.

High-speed flows have been obtained in the low-pressure wind-tunnel by ionizing the gas with high frequency at the exit of the nozzle. This method of heating the plasma avoids obstruction of the flow and contamination of the gas. With 1 kW. high-frequency supply, about 130 watts have been transferred to the gas, which was heated from room temperature to 1,000° C., and Mach numbers up to 3·5 were obtained. It is thought that in nitrogen the electrons recombine with the positive ions to give excited atoms with the release of kinetic energy and that afterwards the excited nitrogen atoms combine with atoms in the ground-state again, releasing kinetic energy. Both stages are accompanied by emission of quanta[17].

The heat transfer from an ionized gas to the walls has been investigated experimentally with a plasma jet of about 2 cm. diameter at subsonic speeds. The walls act as a calorimeter, and an essentially axial magnetic field is produced by a variety of coils, so that the magnitude and structure of the fields can be varied[18] within wide limits up to 3×10^4 gauss.

The velocity of space vehicles is expected to be so large that considerable ionization will be produced in the rarefied gas through which they move. It has been suggested that the hot ionized gas may be guided through a magnetic field, and power drawn from the Hall current for ancillary equipment instead of using a conventional electric generator and other moving parts[19].

Other principles of propulsion have been suggested, such as fusion and light-pressure, and in both cases high specific impulses are theoretically expected. For example, for photons one finds $I_s = c/g$, which is of the order 10^7 sec.

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CANADIAN CÆSIUM-BEAM STANDARD OF FREQUENCY

By S. N. KALRA, R. BAILEY and H. DAAMS
Division of Applied Physics, National Research Council, Ottawa, Canada

A CÆSIUM-BEAM frequency resonator has recently been completed in these laboratories[1]. It is similar in principle to the one reported earlier by Essen and Parry[2] but differs in methods employed for the synthesis and measurement of frequency, and in the detailed design of the atomic-beam apparatus. The potentialities of this technique have already been shown by the measurement of the frequency of the Essen–Parry resonator in terms of Universal Time 2 (ref. 3) and Ephemeris Time (ref. 4). The independent development of the resonator described here was undertaken in view of the importance of this technique in defining the frequency and a time interval. In this resonator, as in the one of Essen and Parry, the frequency of the transition $F=4, m_F=0 \longleftrightarrow F=3, m_F=0$ in cæsium-133 is measured by the use of the Ramsey technique[5] in an atomic-beam apparatus.

The transition region in this atomic-beam apparatus is 80 cm. long and the distance between the source and the detector is 210·5 cm. A beam height of 12·5 mm. and a beam width of 0·25 mm. at the source are used. The focusing magnets are each 20·3 cm. long with a pole gap of 7 mm. giving a field strength of 5,000 oersteds and a gradient of 5,000 oersteds per cm. The stray field from the focusing magnets is reduced almost to zero, by means of magnetic shields. The detector consists of a surface ionizer and an ion collector. A continuously pumped vacuum system is used and the operating pressure is usually less than 1×10^{-6} mm. of mercury. A cancellation of the Earth's magnetic field is obtained by means of two pairs of Helmholtz coils. One of these pairs also provides the operating C field. Fig. 1 shows a general view of the atomic beam apparatus.

The electromagnetic energy required for the resonance transition is obtained from a frequency synthesizer using vacuum pentodes, tetrodes and triodes with a final stage using a silicon diode as a frequency tripler. The driving signal for the synthesizer is obtained from a quartz-crystal oscillator

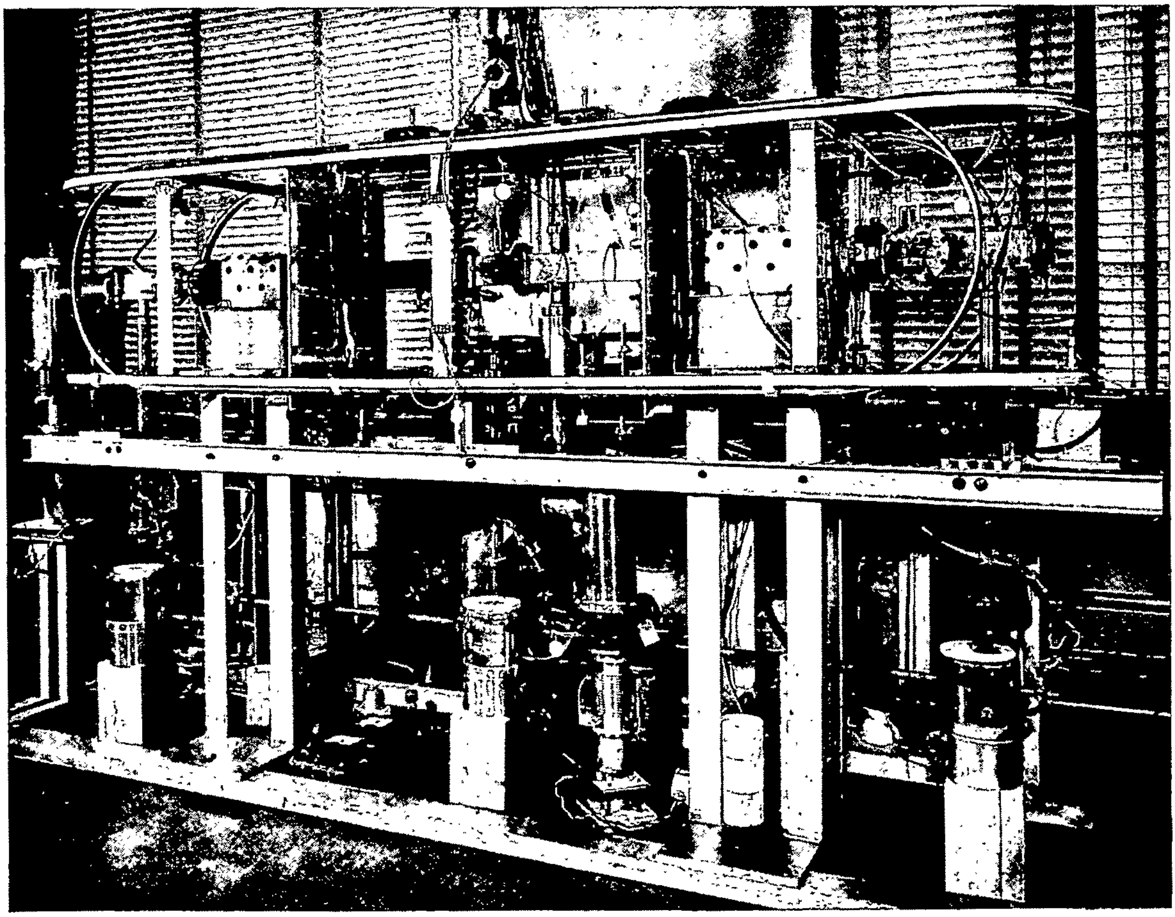

Fig. 1. Atomic-beam apparatus used in cæsium-133 frequency resonator standard

at 5 Mc./s. (nominal frequency) which can be varied continuously to sweep over the resonance line. A small portion of the energy being supplied to the atomic-beam apparatus is taken off by means of a directional coupler and fed to a balanced microwave mixer. This mixer is also fed with the 90,000th harmonic of one of the reference quartz-crystal oscillators[6] at 100 kc./s. The resulting beat note is at 192·6 Mc./s. A second beat is obtained between the first beat signal and the 2,000th harmonic of the reference oscillator, thus giving a signal at 7·4 Mc./s. This frequency is then measured by means of an electronic frequency counter. Fig. 2 shows a block diagram of the frequency-measuring chain described above. Great care has to be taken in keeping down the level of noise because of the high order of frequency multiplication involved. It is possible to make measurements of frequency to an accuracy of ± 1 c./s. or $\pm 1 : 10^{10}$ within 10 sec., which is nearly the limiting accuracy set by the quartz-crystal oscillators.

The source of cæsium atoms is an oven containing a mixture of cæsium chloride and sodium metal and heated to 200° C. The full width (at half intensity) of the resonance transition is measured to be 230 c./s., which is the expected value under the experimental conditions of the beam temperature and the length of the transition region. The frequency of the resonance transition is determined by measuring the frequency at points of equal amplitude on both sides of the resonance. A magnetic field or *C* field of 0·04–0·07 oersted is used such that a correction of the frequency of 1–2 c./s. is needed to obtain the frequency of the zero-field transition. This correction is determined and applied for each observation. The sensitivity of the measurements is about ± 1 c./s. or $1 : 10^{10}$ and the sum of the systematic errors is less than 10 ± 10 c./s.

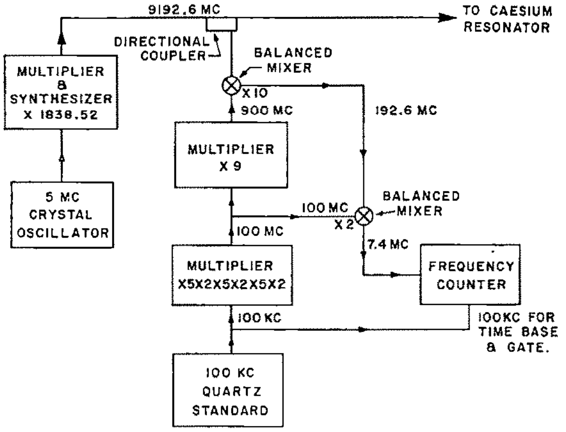

Fig. 2. Block diagram of the frequency-measuring chain used in cæsium-133 frequency resonator standard

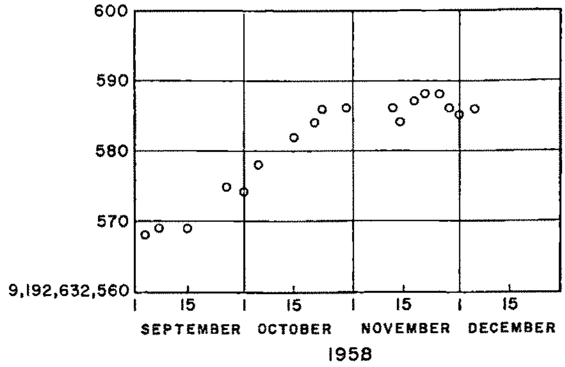

Fig. 3. Ratio of the frequency of the cæsium-133 resonance transition and reference oscillator *AP*. The ordinate expresses the ratio, or the frequency of cæsium-133 resonance under the assumption that the reference oscillator has the exact nominal frequency

The ratio of the frequencies of the cæsium-133 $(4,0 \longleftrightarrow 3,0)$ transition and the reference oscillator *AP* (100 kc./s. nominal frequency) is shown in Fig. 3 for a period of three months. It should be emphasized that the ordinate in Fig. 3 does not represent the frequency of the cæsium resonator in cycles per second, but is simply a ratio determined in the course of measurement of the frequency of one of the reference quartz-crystal oscillators against the cæsium resonator. The second of Universal Time 2 as tentatively determined for September 1958 by the Dominion Observatory, Ottawa, gives 9 192 631 935 ± 50 c./s. as the frequency for the cæsium transition $F = 4, m_F = 0 \longleftrightarrow F = 3, m_F = 0$ at zero field. This value is subject to revision as the unit of time is revised. The magnitude of the uncertainty is governed mainly by the accuracy of the determination of the second.

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OBITUARIES

Mr. F. R. Petherbridge

Frederick Robert Petherbridge died on August 15, 1958, at the age of seventy after a long illness. Before his retirement in 1946 he was widely known and respected in agricultural circles for his work in applied entomology. When first appointed as advisory biologist, under the Ministry of Agriculture and Fisheries, he was expected to advise single-handed on pests and diseases of field and fruit crops throughout the Eastern Advisory Province and also to undertake seed testing. Later, after the appointment of Dr. W. A. R. Dillon Weston as mycologist, Petherbridge devoted his time entirely to pests. Together they were able to win the confidence of East Anglian farmers and to enhance the reputation of the School of Agriculture, Cambridge, both provincially and nationally as a source of advice on pests and diseases.

Robert Petherbridge was born, the son of a fruit dealer, on March 9, 1888, in Allerford, Somerset, and was educated at West Somerset County School and Sidney Sussex College, Cambridge. He obtained first-class honours in the Natural Science Tripos Part I in 1909, and took the diploma in agriculture in 1910. Though lacking inches he was a very good association football player, but it was his keen interest in rugby that most of us will remember, and especially his regular attendance at the Oxford–Cambridge match.

After a short period at Rothamsted Experimental Station, where he was contemporary with Sir John Russell and the late Tom Goodey, he returned to the University School of Agriculture, Cambridge, in 1912, as advisory biologist, continuing in that post until 1946. Being a member of the advisory staff, Petherbridge played only a minor part in formal teaching in the School of Agriculture, but his wide experience and his genial influence was exercised in the supervision of students and the training of research workers, many of whom now hold important posts. His approach to research was essentially practical, and many students fresh from academic training had cause to be very grateful to him for a thorough grounding in field-work.

A good deal of Petherbridge's early work was done on fruit in the Histon-Cottenham and Wisbech areas and later in Essex. He was able to identify at a glance all common varieties of fruit, and the advice he gave was always based on sound practical and economic considerations. But though fruit pests claimed much of his time he was also a pioneer in many other aspects of pest control, particularly those of arable Fenland crops. The onset of the Second World War and the vigorous policy of ploughing up grass led to the setting up of a wireworm team which, besides advising farmers, undertook research on factors affecting population-levels.

Petherbridge began an association with the Committee for Sugar Beet Research in 1934 and initiated work on sugar beet pests. In a determined effort to avoid the difficulties from beet eelworm which had plagued the Continental beet sugar industry, he proposed legislation to regulate frequency of cropping in the important Fenland area. This proposal was accepted and formed the basis of the Sugar Beet Eelworm Order, still in force. Another interesting proposal, which was not accepted, was the eradication of the spindle tree, the winter host of the black bean aphid and a scourge to beet seed and root crops.

Petherbridge's dynamic personality always claimed serious attention at the conference table and at meetings of applied biologists everywhere. He fought enthusiastically and successfully for raising the salary and the status of the adviser and particularly that of his assistants and of junior entomologists elsewhere in the service. He abhorred red tape and he was very disappointed when the old advisory service was dissolved and the National Agricultural Advisory Service was formed in 1946; all members of the team that he had gathered together left the Service at this juncture and he himself retired early. For some years he maintained his interests in association with Pest Control, Ltd., and continued to serve as consultant entomologist to the Royal Agricultural Society of England—a post he took over from the late Cecil Warburton.

F. G. W. Jones

Dr. F. A. Burchardt

Dr. F. A. Burchardt, who died on December 21 in Oxford at the early age of fifty-six, was acknowledged to be one of the most perceptive and vigorous economists of his time. His work at the Universities of Kiel and Frankfurt had, nearly thirty years ago, already established his reputation as a theoretician; but his intellectual and personal integrity was enough to ensure his dismissal as soon as the Nazis took power. For two tense years he worked as economic and financial editor of the *Frankfurter Zeitung*—until this last foothold became untenable. He arrived in Oxford in 1935 with a small research grant from All Souls College. He now had simultaneously to adapt himself to a new academic climate, to master the difficulties of teaching and lecturing in a strange language, and to build a fresh background for his young family.

Burchardt turned his mind to statistics and applied economics: indeed, he did much to establish empirical economic research in Oxford. He joined the staff of the Institute of Statistics, eventually becoming its director in 1949. He had been elected a Fellow of Magdalen College the year before, and in 1950 was appointed reader in economic and social statistics in the University. During 1952 he went to Stanford University as visiting professor; in the same year he became a governor of the National Institute for Economic and Social Research; in 1954 he was elected a member of the International Statistical Institute and a Faculty Fellow of Nuffield College; he reported for the European Productivity Agency in 1955, and worked in the Economic Commission for Europe during 1956–57. His help was welcomed in many other fields—among them that of adult education both in Britain and in Germany.

He had an immense capacity for work, and combined his many activities with devoted service to the Institute of Statistics, his College, and the University. An unfeigned interest in other people's views, a startlingly quick perception of what they were trying to say, and a faculty—almost an instinct—for distinguishing truth from mere plausibility made him an outstanding teacher. At the Institute, he inaugurated many pioneering projects in applied economics. Although he provided an unfailing stimulus to his colleagues, never grudging them detailed criticism, he never took credit and always encouraged them to claim, and to achieve, their independence. Those who knew him will always remember his intellectual vitality, his ready humour, and his utter unselfishness.

K. G. J. C. Knowles

The Hon. Mrs. Ursula Grant Duff

The Hon. Ursula Grant Duff, widow of Lieut.-Col. Adrian Grant Duff (killed in action in 1914), died on January 15, a few days before her seventy-fourth birthday, and was buried at High Elms, Farnborough, Kent. Her father was Sir John Lubbock (later Lord Avebury); her maternal grandfather was the pioneer archæologist, General Pitt-Rivers; and at High Elms, where Charles Darwin was a neighbour, she grew up in one of the liveliest centres of intellectual ferment in England.

Many sorrows followed the death of her father in 1913, but she continued the High Elms tradition at her Chelsea home with infectious gaiety and unassuming devotion to the improvement of personal, intergroup and international relations. The leading figures of the biological and social sciences were among her frequent guests, but there were always younger workers and representatives of other disciplines to meet them. Her relations with *Nature* and its contributors were particularly close.

Her own interests ranged from liberal rationalism and the rights of women to eugenics and constructive forestry; but all were linked in her mind as ways to the good life, and all arose from the scientific attitude in which she had been bred. Unfortunately, she could attempt no major synthesis, though she wrote and lectured on these questions with judgment, wit and uncompromising humanism.

She also did much to perpetuate her father's reputation, notably by her excellent symposium on "The Life and Work of Lord Avebury" (1924); and she has added to it the esteem in which she was widely held.

Cedric Dover

NEWS and VIEWS

Forestry at Oxford: Sir Harry Champion, C.I.E.

The retirement of Sir Harry Champion as professor of forestry at Oxford and the consequent appointment of Mr. M. V. Laurie serve to mark a notable period of development. Sir Harry succeeded in 1940, on the death of Prof. R. S. Troup, and at a time when changes in India, counterbalanced by the rising importance of forestry in the Colonies, necessitated re-organization and development: the increasing need for research was also being realized. It has been Sir Harry's main achievement to organize and carry through successfully the changes thus required. Outstanding points have been the change of forestry to an Honours School; the increasing development of postgraduate work; the occupation of the new building in 1950; and the necessary enlargement of staff and work. Sir Harry's wide experience and energy will be much missed and all hope that they will find further fruitful occupation.

Prof. M. V. Laurie

Sir Harry was central silviculturist at Dehra Dun, India, before going to Oxford, and Mr. M. V. Laurie followed him there in that post. Now he is again following him, this time at Oxford. Mr. Laurie was born in 1901 and trained at Cambridge. He retired from the Indian Service in 1946 and became chief research officer in the Forestry Commission. He comes thus with the experience in both tropical and temperate forestry which is desirable at Oxford. The prospects of the present time indicate that change and development will still be necessary in forestry, and he will receive all good wishes for his future work.

Organic Chemistry at Perth, Australia: Prof. D. E. White

Dr. D. E. White has been appointed to the recently established chair of organic chemistry in the University of Western Australia, Perth. Prof. White graduated from the University of Sydney in 1930 with first-class honours in organic chemistry, and later obtained the D.Phil. (Oxon.) for his work with Sir Robert Robinson during 1934–36. After experience with I.C.I. (General Chemicals), Ltd., at Widnes, Lancs, as tutor at St. Andrew's College, Sydney, and biochemist in the School of Public Health and Tropical Medicine in Sydney, he was appointed lecturer in organic chemistry in the University of Melbourne in 1940 and senior lecturer in charge of organic chemistry in the University of Western Australia in 1943. From the time of his arrival in Western Australia he has taken advantage of the existence of a unique natural flora, and has devoted his research interests to the organic chemistry of plant products.

White has been associated with the identification of 'callitrol' as citronellic acid, the elucidation of the structure of ravenelin, the synthesis of myristicin, a survey of Australian anthocyanins and the identification of genistein as the major œstrogen in subterranean clover. In recent years he has been working on the structures of sesquiterpene, diterpene and triterpene compounds isolated from Western Australian plants and has built up an active and well-equipped research school now numbering about twelve honours and Ph.D. students. In addition to his research activities, White has taken a keen interest in both undergraduate teaching and in extramural activities. He was president of the Royal Society of Western Australia during 1955–56 and is now president of the Western Australian Branch of the Royal Australian Chemical Institute and dean of the faculty of science at the University of Western Australia.

Andreas Sigismund Marggraf (1709–82)

'The second father or renewer of chemistry', Andreas Sigismund Marggraf was the son of Henning Christian Marggraf, chief apothecary to the royal court at Berlin, and was born 250 years ago on March 3, 1709. He studied chemistry, pharmacy, medicine, mineralogy and metallurgy at Berlin, Halle and Freiberg. In 1754 he became director of the chemical laboratory of the Berlin Academy of Science (later called Royal Prussian Academy of Science) and of its physics class in 1760. An able experimenter, a skilled analyst and a voluminous writer, he was responsible for a number of far-reaching contributions to chemistry, chemical industry and national economy. He made the microscope a useful aid in the chemical laboratory; worked out a cheap method for the preparation of phosphorus and of phosphoric acid, which laid the basis for important industries; prepared phosphorus pentoxide and showed that phosphorus is contained in urine as phosphates. He produced potassium cyanide, demonstrated its capacity of forming double salts with those of the heavy metals, and introduced the ferro-ferricyanides as reagents for iron. It was his preparatory work that led to the isolation by Sir Humphry Davy of the metallic elements potassium, sodium and magnesium. In 1768 Marggraf obtained hydrogen fluoride by the distillation of fluorspar with sulphuric acid. The value of his discovery of sugar in the sugar beet was only appreciated during the continental blockade of France in 1806. Marggraf died in Berlin on August 7, 1782. His collected writings were published under the title "Chymische Schriften" in two volumes (1761, 1767).

The Heaviside Manuscripts

The Institution of Electrical Engineers' "Heaviside Centenary Volume" (1950) contained a long article by Mr. H. J. Josephs, of the Post Office Research Station, describing the contents of various unpublished Heaviside manuscripts in the possession of the Institution; much of the material would have found a place in the projected but never completed Vol. 4

of Heaviside's "Electro-magnetic Theory". In 1957, in a house at Paignton, once occupied by Heaviside, a further collection of his manuscripts was discovered; these are now described by Mr. Josephs in the Institution's Monograph No. 319.

Some of these notes seem to be corrections and amplifications of Vol. 2 of the "Electro-magnetic Theory", which Heaviside would have incorporated in this volume had not the publishers insisted on a simple reprinting of the articles in *The Electrician* which formed the substance of the treatise. They show the emphasis placed by Heaviside on a symmetrical formulation of the electro-magnetic equations which, while not improperly called Maxwell's, seem to have been first stated explicitly by Heaviside; and they show his interest in, and attempts to establish, a unified field theory embracing both electromagnetic and gravitational phenomena, based on a general energy-flow equation. They also contain much about Heaviside's operational calculus, particularly in connexion with fractional differentiation, and suggest that Heaviside explored the idea of treating p not simply as the differentiation operator, but as the parameter in an integral transform, a point of view much closer to present-day interpretations of his calculus.

Whether or not a careful analysis of the large mass of papers found at Paignton would now be worth while, Mr. Joseph's article can only increase respect for Heaviside as an unorthodox but brilliant mathematician. Mr. Joseph revives the comment that Heaviside's operational methods made no appeal to mathematicians because such methods did not conform to the standards of rigour fashionable at the time; this is not in agreement with the conclusions reached by Prof. J. L. B. Cooper, who has discussed the point in considerable detail in an article in the *Mathematical Gazette* for February 1952.

Isaac Newton Telescope

FINANCIAL approval has been given to proceed with the construction of the proposed 98-in. Isaac Newton telescope which will be erected at the Royal Greenwich Observatory, Herstmonceux. This project was sponsored by the Royal Society, at the instance of the Royal Astronomical Society, and approved in principle by the Treasury and the Board of Admiralty in 1946. The design of the instrument received careful consideration by the scientists concerned, and development work was undertaken. In 1955 it was decided that the new Astronomer Royal should, on appointment, be given the opportunity of considering the final form of the telescope, and a quotation for construction of the instrument was obtained in November 1956. Owing to lack of funds, it was not then possible, however, to proceed with the actual construction. The new telescope, which will be the largest in the United Kingdom, will be used by visiting astronomers as well as by the staff at the Royal Observatory. The cost of the whole project, including erection and preparation of the site, is estimated at £660,000 at present prices, and will take five to six years to complete. Expenditure will be shared equally between the Treasury and the Admiralty.

The Isaac Newton telescope will be designed for use at the prime focus, Cassegrain focus, and coudé focus. Special attempts will be made to design a Cassegrain combination suitable for astrometry. The telescope tube will be held in an open fork with no north support; the Cassegrain focus will be reached from a platform carried by the telescope itself. It is intended to carry out an extensive programme of parallax work at the Cassegrain focus, using the large aperture to observe much fainter stars than are accessible to the comparatively small refractors now used on parallax work. The telescope is very flexible as regards choice of programme, and at present it is intended to concentrate the spectroscopic programmes on the precise determination of radial velocity, especially in those cases where individual stellar velocities may be supposed to be important in connexion with problems in stellar dynamics. In particular, it is planned to provide a large grating spectrograph at the coudé focus, with cameras of approximately 100-in., 60-in. and 30-in. focus. The prime focus will be available for the direct photography of stellar fields of interest in radio astronomy, and will be equipped with a field-correcting lens.

Effects of the Aurora on Radio Reception

A RESEARCH station to study the effects of the aurora on radio reception is to be set up on the site of a former radar station at Hillhead, near Fraserburgh, in Aberdeenshire. This investigation, part of a programme of ionospheric studies, will be undertaken by the Stanford Research Institute of America in collaboration with scientists from the Royal Radar Establishment of the Ministry of Supply. Observations will be made with a large parabolic reflector about 140 ft. in diameter brought from America. The experiments are expected to start in the late spring or early summer and will last one or two years. The cost will be borne by the Stanford Research Institute. The Aberdeenshire site has been chosen because of its geographical suitability for the study of auroral phenomena. There will be no radiation danger, and interference with radio and television will be prevented by the operating conditions laid down for the installation. There should be no restrictions on agricultural work, except that the vicinity of the installation must be protected from damage by livestock.

Biochemistry at the Royal College of Surgeons

IN days gone by, surgical shock was interpreted in terms of vaso-motor reactions and nervous responses to the stimulus of a severe injury. To-day attention is directed rather to the metabolic (chemical) response to injury, and since a chemical mechanism is now known to underlie the phenomena of shock, its treatment must be chemical also. Hitherto the process of wound healing has been regarded as a matter of cellular and vascular processes, explicable on a histological basis. But there was a mysterious initial phase when nothing could be seen to be going on in the wound, sometimes referred to as 'the lag period'. Recent research has shown that during these early days there is intense chemical activity in the wound, resulting in the accumulation of certain substances which are essential for the natural process of repair and without which the lag period may be indefinitely prolonged. There are profound biochemical changes in patients suffering from cancer, and furthermore there are tumours which are known to depend for their growth upon certain chemical substances, the deprivation of which can result in such diminution of growth as to suggest the possibility of treating cancer by chemical means. These are only examples to indicate the importance of biochemistry in surgery to-day, and it is no wonder that the Council of the Royal College of Surgeons decided some time ago to establish a sub-department of biochemistry in the Department of Physiology, with the dual purpose of promoting research and of amplifying the educational facilities which the College provides for postgraduates studying the basic medical sciences. The College has long looked forward to establishing a chair of biochemistry, and is deeply indebted to Mr. Jack Cotton for his recent gift of £100,000, which will make this possible.

Arrival of *Methane Pioneer*

Methane Pioneer, which left the Gulf of Mexico on January 31, arrived at Canvey Island, Essex, on February 20 with an experimental cargo consisting of 2,000 tons of liquid natural gas (methane) from one of the Gulf Coast oilfields. After liquefaction, which reduces it to 1/600th of the volume occupied in gaseous form, it was loaded into five special tanks in *Methane Pioneer*, which is owned jointly by the Gas Council of Great Britain and Constock International Methane, Ltd., of the United States. The tanks are of aluminium with a 12-in. insulation of balsa wood and an outer jacket of steel. The liquid will be pumped from *Methane Pioneer* and through an insulated pipeline from the jetty to two storage tanks, each with a capacity of about 1,000 tons of methane. One has been built for the North Thames Gas Board by the Whessoe Company, Ltd., of Darlington; the other by the A.P.V. Company, Ltd., of Crawley. Although these shore storage tanks are heavily insulated there will be a continuous boil-off of gaseous methane, and this material will be contained in a small gas-holder of the dry-sealed Wiggins type, whence it will be pumped into the mains system. Liquid methane will be vaporized by heat exchange with water or steam, and there is no intention at this stage of making use of the refrigerating capacity of the methane, which is at −260° F. The liquid will be converted to gas under pressure, and this pressure will be used to convey the gaseous methane into the transmission lines of the North-Thames Gas Board. A new transmission line has been laid from Canvey Island to connect with a high-pressure main already in existence between Shellhaven and Romford Works, and the gaseous methane will mix with refinery gases from the Shellhaven refinery. The town's gas supplied by the Board is distributed at 500 B.Th.U./ft.^{3}, while the methane has a calorific value of 1,000 B.Th.U./ft.^{3}, and reforming of the methane into gas of 500 B.Th.U./ft.^{3} will be carried out at Romford by the Onia-Gegi catalytic process. The gas after reforming will have similar characteristics to gas normally produced from coal and will be suitable in every way for consumers' appliances, with the added advantage that it will be free from sulphur. If these trials prove successful, both technically and economically, consideration will be given to the import of liquid methane on a much larger scale. Vessels carrying some 30,000 tons will probably be required in order to secure real economy.

Noise in Industry

In a written reply to a question about studies of the incidence and effects of noise in industrial establishments, Mr. H. Nicholls, as representing the Lord President of the Council, said in the House of Commons on February 13 that the National Physical Laboratory undertook surveys of noise for industry and advised on appropriate treatments to reduce noise inside and outside offices, factories, etc., caused by machinery and equipment used in the factory. The Laboratory also made fundamental investigations on the 'subjective loudness' of different types of noise. The Building Research Station was conducting surveys related to factory design, construction and use, and the effect of factory noise on neighbouring areas. Several grant-aided research associations were also actively interested in noise abatement although their research was mostly at an early stage. These studies were in addition to those of the Medical Research Council attempting to define the normal deterioration that occurs with age and the extent to which this may be modified by exposure to industrial noise. Papers had been and would continue to be published by the Stationery Office and in the technical press.

A Register of Historic Aircraft

A first practical step towards a national aeronautical museum was taken at a meeting held at the Royal Aeronautical Society at the end of January under the chairmanship of Mr. Peter G. Masefield, president-elect of the Society. At this meeting, which was attended by twenty-six representatives of Government departments and other public bodies, it was agreed to compile a register of aircraft of major historical importance in Great Britain with the view of their preservation. The need for a national British aeronautical museum has been felt for a long time by many in the aircraft industry who are anxious that historic aircraft should be preserved. Since the Royal Aeronautical Society acquired the aircraft of the Nash Collection of Early Mechanical Transport in 1953, so that these historic aircraft should remain in Britain, the Society has hoped that they would eventually form part of a national aeronautical museum. The decision to compile a Central National Register means that the whereabouts and condition of all historic aircraft still in Britain will be known and plans to ensure that they are not destroyed can be put in hand. The number of these valuable and irreplaceable aircraft is steadily dwindling because of a lack of national policy. A sub-committee under the chairmanship of Air Commodore A. H. Wheeler, trustee of the Shuttleworth Collection, has been formed to supervise the preparation of the Register. The Royal Aeronatical Society has already been greatly helped by many enthusiasts, but it is clear that there must be many relics still in private hands, and the Society appeals to all who possess old aeroplanes or aero-engines or who know where they are to inform the Society of their location and condition so that, if possible, they may be added to the Register. Information should be sent to Mr. A. S. C. Lumsden, Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

Institution of the Rubber Industry in South Africa

The first steps are being taken to establish a South African Section of the Institution of the Rubber Industry, consisting of a central Council in Johannesburg with branches in Johannesburg, Durban and Port Elizabeth. The aims of the new Section will be to promote the development of polymer science and technology, to encourage technical education and provide a means of association between persons engaged in the rubber industry in South Africa. South African companies and personnel engaged in rubber and plastics manufacture are invited to apply for membership of the Section. The addresses of the honorary secretaries are as follows: *Johannesburg*,

F. C. Moore, Durham Raw Materials, P.O. Box 4142, Johannesburg; *Durban*, A. J. Robertson, P.O. Box 1515, Durban, Natal; *Port Elizabeth*, W. Pickup, P.O. Box 3062, North End, Port Elizabeth.

The Translations Bulletin

THE *Translations Bulletin* of the Lending Library Unit of the Department of Scientific and Industrial Research, the first issue of which appeared in January, replaces the *Translated Contents Lists of Russian Periodicals* previously issued by the Unit. In so far as it also includes articles on scientific or technical developments in the U.S.S.R., the claim that it is a new publication is justified and there are also lists of translated Russian books in print or printing; translated or being translated; and suggested for publication. It represents also a considerable modification of the arrangements for co-operative Russian translations. In the new *Bulletin* lists are given of cover-to-cover translations of Russian periodicals and of translations of Russian articles available from the Library Lending Unit. In future, however, instead of referring to the *Translated Contents Lists of Russian Periodicals* previously issued by the Department at the same price as the new *Bulletin*, it will be necessary to subscribe to the *Monthly Index of Russian Accessions*, available from H.M.S.O. (U.S.A. Section), P.O. Box 569, London, S.E.1, the subscription to which is about £5 7*s*. 6*d*. a year. This has the advantage of being more comprehensive than the *Monthly Index*, but apart from being a little later, its greater bulk may be a disadvantage in the circulation to departmental specialists on whom a university librarian, for example, will doubtless rely for requests for translations. The decision whether a translation shall be made, however, rests with the Department itself instead of with the potential user. Under the previous scheme a translation would be made at the request of two or more users, the cost depending on the number of requests received. This may, however, become less important as the co-operative scheme with the National Science Foundation for cover-to-cover translation of periodicals develops, under which twenty-four periodicals are already listed for translation in the January issue of the *Bulletin*.

Overseas Geology and Mineral Resources

THE quarterly bulletin of the Overseas Geological Surveys, formerly known as *Colonial Geology and Mineral Resources*, and published by H.M. Stationery Office, London, has been renamed *Overseas Geology and Mineral Resources* as from Vol. 7 (1), 1958, in order to be more in keeping with the changing status of the territories for which it caters. The bulletin will continue to cover topics concerning all the territories, whether dependent or independent, that previously came within its purview.

Australian Defence Standards Laboratories

THE 1956 report of these Laboratories has recently been released. It contains an interesting account of a surprisingly wide range of activities. The scope of the investigations is indicated by the inclusion of studies of such diverse subjects as detergents, radio spectroscopy, paint, textiles, rubber, radiological physics and viscometry. Worthy of special mention are three items of considerable interest. First, xerography has been explored with particular reference to the employment of liquid developers of high volume-resistivity such as carbon tetrachloride. By using such liquids a considerable improvement in resolution has been achieved. This has important applications for radiographic purposes and in continuous-tone photography. Second, a new method for graticule production—the interstitial process—has been developed. This has already been described in *Nature* (January 24, p. 223), where the Laboratories were incorrectly named 'Reference' instead of 'Defence Standards Laboratories'. Third, work on a multi-cell-unit dry battery has produced promising results. After manufacture, the battery is dehydrated under heat and vacuum. It is then in a suitable condition for storage. When required for use, the battery is activated by the addition of water.

Lady Tata Memorial Trust Scholarships and Fellowships

THE Trustees of the Lady Tata Memorial Trust invite applications for grants, scholarships or fellowships for research on diseases of the blood, with special reference to leukæmia, in the academic year beginning on October 1, 1959. In view of the affinity between leukæmia and other forms of neoplastic disease, candidates with programmes of research on any aspect of malignant disease which may throw light on problems of leukæmia will also be eligible. Grants of variable amount are made for research expenses or to provide scientific or technical assistance for senior workers. Scholarships are awarded for the personal remuneration of workers carrying out approved research under suitable direction; their normal value will be £600 per annum. In addition, the Trustees may award one or more Lady Tata Memorial Research Fellowships to workers with considerable research experience; the stipends of these Fellowships will be at the rate of £1,200 per annum. Further particulars and forms of application can be obtained from the Secretary of the (European) Scientific Advisory Committee, Lady Tata Memorial Trust, Chester Beatty Research Institute, Fulham Road, London, S.W.3. Applications must be submitted before March 31.

University News: Bristol

MISS MARGARET RANDALL has been appointed organic chemist at the Long Ashton Research Station.

The University has received the following gifts and grants, among others: £8,341 from the British Empire Cancer Campaign for cancer research to be carried out in the Departments of Pathology, Physiology and Surgery; £2,500 from the Department of Scientific and Industrial Research, as a renewal of grant for Prof. C. F. Powell's work in the Department of Physics; £1,492 from the Agricultural Research Council to the Department of Veterinary Medicine for research on experimental transmission of lymphoid leukosis; £1,172 from the Agricultural Research Council to the Department of Physiology for research on bovine acetonæmia.

Liverpool

THE following appointments were recently made: P. E. Doak, to be lecturer in applied mathematics; S. L. Dixon, to be lecturer in mechanical engineering; D. Allan, to be lecturer in applied veterinary pathology.

The Night Sky in March

NEW moon occurs on Mar. 9d. 10h. 51m. U.T. and full moon on Mar. 24d. 20h. 02m. The following conjunctions with the Moon take place: Mar. 1d.

10h., Jupiter 3° S.; Mar. 3d. 22h., Saturn 4° S.; Mar. 12d. 00h., Venus 0·1° N.; Mar. 16d. 19h., Mars 7° N.; Mar. 28d. 18h., Jupiter 3° S.; Mar. 31d. 06h., Saturn 4° S. In addition to these conjunctions with the Moon, Mars is in conjunction with Aldebaran on Mar. 4d. 14h., Mars being 7·5° N. There is a partial eclipse of the Moon on March 24, visible at Greenwich. This is one of the final eclipses of a series which began in 985 and which will end in 2013. Mercury is favourably situated for observation during the first three weeks of the month. It is an evening star, visible for a short time after sunset. It sets at 19h. 45m. on March 15. Venus is an evening star, visible in the south-west after sunset. Conditions are steadily becoming more favourable for observation. Venus sets at 19h. 55m., 20h. 40m. and 21h. 35m. on March 1, 15 and 31, respectively; its stellar magnitude is $-3 \cdot 4$. Its distance decreases during the month from 137 to 122 million miles and the visible portion of the apparent disk decreases from 0·900 to 0·828. Mars is moving eastwards among the stars and is in Taurus throughout March. It sets at 2h. 05m., 1h. 50m. and 1h. 25m. at the beginning, middle and end of the month, respectively. Its stellar magnitude decreases from $+0 \cdot 8$ to $+1 \cdot 3$, its distance from the Earth increasing from 119 to 148 million miles. Mars is easily observed during the evening, but conditions are becoming less favourable. Jupiter rises at 1h. 10m., 0h. 20m. and 23h. 10m. on March 1, 15 and 31, respectively; it is near β Scorpii. The stellar magnitude of Jupiter is $-1 \cdot 8$; conditions for observation are not very favourable. The distance of Jupiter is approximately 460 million miles. Saturn is a morning star in Sagittarius, rising at 3h. 55m., 3h. 00m. and 2h. 00m. at the beginning, middle and end of the month, respectively. Its stellar magnitude is $+0 \cdot 8$ and its distance approximately 960 million miles. Conditions for observation are not favourable. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Mar. 13d. 19h. 03·8m., 31 Ari. (*D*); Mar. 21d. 0h. 19·2m., A^1 Cnc. (*D*); Mar. 21d. 2h. 13·4m., A^2 Cnc. (*D*); Mar. 21d. 21h. 00·4m., 6 Leo. (*D*); Mar. 29d. 3h. 47·7m., χ Oph. (*R*). *D* and *R* denote disappearance and reappearance, respectively. The vernal equinox occurs on March 21d. 09h.

Announcements

DR. NYMAN LEVIN, deputy director of the Weapons Group of the United Kingdom Atomic Energy Authority since July 1958 (see *Nature*, **182**, 155; 1958), has been appointed director of the Group in succession to Sir William Penney. Sir William will succeed Sir John Cockcroft as the Authority's member for research when Sir John takes up his mastership of Churchill College. Dr. Levin is succeeded as deputy director of the Weapons Group by Mr. E. F. Newley.

MR. J. S. FULTON, principal of the University College of Swansea, has been appointed vice-chancellor of the University College of Sussex which is to be built on the outskirts of Brighton.

MR. ERIC K. COLE has been elected an honorary member of the British Institution of Radio Engineers in recognition of his services to the radio and electronics industry and profession. Mr. Cole is chairman and managing director of the firm bearing his name, which he founded in 1926.

VIRGIL H. DISNEY, director of electrical engineering research at Armour Research Foundation, has been elected president of the National Electronics Conference for 1959, the next meeting of which is to be held at the Hotel Sherman in Chicago during October 12–14. Further information can be obtained from the U.S. National Electronics Conference, 84 East Randolph Street, Chicago 1, Illinois.

DISCUSSIONS on expanding Anglo-Soviet educational, cultural, scientific and other exchanges during 1959–60 will begin in Moscow on March 24 between the Soviet Relations Committee of the British Council and the Soviet State Committee for Cultural Relations with Foreign Countries. The talks are expected to last about a week. The Soviet Relations Committee of the British Council was set up with Government support in 1955; it provides a representative organization to encourage, sponsor and organize Anglo-Soviet exchanges in various fields.

THE Clough Memorial Research Fund of the Edinburgh Geological Society is available for geological research in Scotland and the north of England (Northumberland, Durham, Cumberland, Westmorland and Yorkshire). Grants for the period April 1, 1959–March 31, 1960, will be made shortly, and applications, stating the nature of the proposed research, should be sent before March 31 to the Secretary, Clough Memorial Research Fund Committee, Edinburgh Geological Society, Synod Hall, Castle Terrace, Edinburgh 1.

BY arrangement with the Polish State Publishing House for Scientific Literature, Warsaw, an exhibition of Polish scientific books is being held by the Oxford University Press in Oxford at 116 High Street during February 21–March 7. A similar exhibition is being held in Cambridge at Messrs. Heffer during March 4–14, and in Glasgow at Messrs. John Smith during March 2–14. Oxford University Press books will in turn be exhibited in a number of Polish cities, including Warsaw, Cracow, Poznan, Lodz and Wroclaw. Subjects covered by the exhibition are anthropology, archæology, bibliography, biology, chemistry, economics, geography, history, law, linguistics, mathematics, philology, philosophy and physics.

THE Scottish Group of the Nutrition Society is to hold a symposium on Obesity, on April 4 in Glasgow. Those interested who are not already members of the Society may write for further particulars to Dr. J. Davidson, The Rowett Research Institute, Bucksburn, Aberdeenshire.

THE British Agricultural History Society and the Economic History Society are to hold a joint conference on Agriculture and Rural Life at Wye College, during April 10–13. Further details can be obtained from Mr. J. D. Sykes, Department of Agricultural Economics, Wye College, Nr. Ashford, Kent.

AN international symposium on experimental biology is to be held in commemoration of Lazzaro Spallanzani (1729–99) at his birthplace, Reggio Emilia, during May 2–9. Further information can be obtained from Prof. Carlo Jucci, Istitute 'L. Spallanzani', Palazzo Botta, Pavia.

IN his review of "Bibliography of Food", by E. A. Baker and D. J. Foskett, published in *Nature* of February 7, p. 351, Dr. Magnus Pyke states that "the authors do list Plimmer's historical tables of food composition and omit to mention the workaday ones of McCance and Widdowson". The latter tables are in fact listed on p. 285 and are indexed in both author and subject indexes.

RELAXATION PROCESSES

An informal discussion on "Relaxation Processes" was held under the auspices of the Faraday Society in the Department of Chemical Engineering, at the Imperial College of Science and Technology, London, on November 27. About eighty people from universities and industrial research centres both in Great Britain and abroad were present.

The chairman, Prof. A. R. Ubbelohde, welcomed the visitors and stressed the modern importance of relaxation techniques in the study of a wide variety of rate processes of interest to the physical chemist. The use of methods involving cyclic stresses could provide a valuable means of studying rate processes in systems only slightly perturbed from their equilibrium states, and made possible the correlation of rates with thermodynamic functions. This was of particular interest in the cases where the relaxation times could be associated with specific molecular mechanisms.

Prof. C. J. F. Böttcher (University of Leyden) presented a paper on the phenomenological study of dielectric relaxation. He considered a dielectric with polarization (strain) in the same direction as the applied field (stress), for the case in which there is a lag between stress and strain. If the stress is prescribed to rise and fall as a simple step-function with time, then the strain shows a simple retardation effect. If, on the other hand, the strain is prescribed to have a step form, then the stress required to effect this shows a relaxation effect. Since in practical dielectric measurements we work with a prescribed stress, it would seem logical to refer to the measured time-constant as the retardation time. He outlined the equations describing the variation of dielectric constant and of the loss factor with frequency. Although the retardation and relaxation times are not in general the same, they may be shown to have a simple mathematical connexion in this case and each can be related to a molecular relaxation time, so that the distinction between retardation and relaxation is in the nature of a formal rather than a physico-chemical one. The dependence on temperature of the molecular relaxation time can be understood by considering the relaxation mechanism as an Eyring type rate-process. Identification of the molecular process responsible for the macroscopic relaxation is facilitated by the experimental fact that a single relaxation curve is often obtained.

Illustrating the comparatively simple behaviour which could occur in complex molecules, Prof. Böttcher reported measurements on bromobenzene and cyclohexanol, each of which showed a single relaxation curve and mixtures of which showed only two relaxation times shifted towards each other, rather than a complex distribution of relaxation times.

Dr. Vera Daniel (Electrical Research Association, Leatherhead) described the results of measurements on a group of long-chain alcohols where anomalous dielectric constants (higher than those expected from the number of hydroxyl groups) are connected with the existence of polymeric forms of hydrogen bonds, so that the energy differences between the two forms of different polarization are small. Co-existence of these different forms is unlikely in a perfect crystal but likely at structural imperfections. Measurements were described on a variety of crystals grown from the melt or solution, containing different proportions of structural defects. These measurements, together with those of other investigators, indicate that chains of hydrogen bonds become polarizable in relation to some kind of flaw. For a maximum dielectric constant fairly long chains are necessary, combined with a sufficiency of flaws. The flaws occupy space and a texture was suggested in the materials which would give suitable flaws to explain the dielectric properties and a number of other properties of the crystals.

Mr. W. Reddish (Imperial Chemical Industries, Plastics Division), in a paper on solid polymers, indicated that the way in which polymers soften as temperature increases is dependent on time and hence possess relaxation characteristics. Results of detailed measurements of harmonic dynamic mechanical moduli and losses show strong correlation with measurements of dielectric relaxation obtained at the same frequency, in the case of several important polar polymers. Measurements of the mechanical moduli over a wide range of temperature together with dielectric measurements over a wide range of frequency show that cases of softening by a single process are rare; often two or more processes are observed widely separated on the temperature scale, a polycarbonate for example showing processes 250° C. apart. The number of processes possible seems to be related to the number of separate modes of rotational motion which can occur in the molecule, relatively free rotation of small groups occurring at low temperatures. These rotational motions may be inhibited in crystalline regions.

After comparison of dielectric and mechanical data for a range of compounds (especially when side-chains are varied systematically), it has sometimes been possible to suggest that particular relaxation processes are associated with motions of particular molecular groupings. Detailed models were discussed for polymethyl methacrylate and polymethyl chloracrylate. Another phenomenon of interest was that certain modes of motion observable mechanically but not electrically for non-polar polymers can be excited by adventitious dipolar impurities; for example, this function is attributed to carbonyl groups in polyethylene. Dielectric data for three processes for linear and branched slightly oxidized polyethylene were represented by means of solid models shown at the meeting.

In general discussion, Dr. C. W. Bunn (Imperial Chemical Industries, Plastics Division) raised a number of points connected with the hydrogen-bonded structures suggested by Dr. Daniel. Dr. R. B. Beevers (Courtaulds, Maidenhead) pointed out that the high values of the dielectric constant obtained by Dr. Daniel for specimens prepared from the melt may possibly arise as a consequence of the formation of a meso-phase in the melting region and suggested that it would be worth while to determine if such a meso-phase existed.

Prof. G. Gee (University of Manchester) criticized methods of analysing the dependence of relaxation times on temperature by means of the equation:

$$\log \tau = \log \tau_0 + E/RT$$

He pointed out, however, that a more precise analysis still gave remarkably large activation energies associated with the relaxation process in high polymers and suggested that this was because these were concerned with disturbances over large molecular areas of the material and not only with one bond.

Questions by Prof. Ubbelohde, Dr. Mansel Davies (University College, Aberystwyth) and Mr. B. Warburton (Distillers Co.) on matters arising from his paper were answered by Mr. Reddish. Dr. Greaverson (Shell) presented measurements on mechanical relaxation in polyethylene, Dr. G. Allen (University of Manchester) measurements on mechanical relaxation on rubber, and Dr. C. Brot (Paris) reported dielectric studies on liquid mono-alcohols of medium chain-length which showed three dispersion regions; these he interpreted in terms of molecular mechanisms.

In the second part of the meeting, Dr. J. H. Andrea (Imperial Chemical Industries, Research Department) presented results of ultrasonic relaxation measurements in liquids, ranging from low frequencies (100 kc./s.) where chemical equilibria involving rotational isomers may be perturbed by the sound wave and ultrasonic absorption observed, to the high frequencies (100 Mc./s.) where association–dissociation equilibria or slow redistribution of energy between translation and vibration may give rise to measurable ultrasonic absorption.

Dr. Andrea outlined ultrasonic measurements made by Dr. Lamb and his collaborators (Imperial College of Science and Technology, London) which gave values for the heats and entropies of activation in the passing from one rotational isomeric form to another, with particular reference to the substituted cyclohexanes. This gave a new method of measuring potential barriers hindering internal molecular rotation. He described the existence of an anomalous absorption region in toluene the origin of which is as yet unexplained.

Mr. J. Barlow (Imperial College of Science and Technology, London) described research in conjunction with Dr. Lamb, in which ultrasonic techniques were being used to determine the shear mechanical impedance of lubricating oils, as part of an investigation into the influence of the relaxation behaviour of molecules on lubrication. Measurements had been made for frequencies of the cyclic shearing stress in the region 10^4–10^8 c./s.: the effective range could be extended by variation of the temperature and pressure of the oil under test. All the experimental results for a given oil could be reduced to a single curve for each component of the complex shear modulus. This information was then analysed in terms of a spectrum of relaxation times. Qualitative correlation could be made between the relaxation spectrum and the proportions of the various hydrocarbon types in the oil.

Dr. J. C. McCoubrey (Imperial College of Science and Technology, London) gave a résumé of work on ultrasonic relaxations in gases which could be used to give quantitative transition probabilities for the process in which a molecular vibration was de-excited from the first vibrational level to the ground-state by a collisional mechanism. Some theoretical explanation of these transition probabilities in terms of molecular parameters could be given, but this was inadequate to explain the dependence of ultrasonic relaxation times on temperature. A new technique involving the use of interferometry to study the changes in density across a shock front in gases in which ultrasonic relaxation had been observed could yield measurements of the translation–vibration transition probabilities at temperatures up to 3,000° K., providing valuable tests for theories over a wide temperature-range.

In the general discussion, possible explanations of ultrasonic relaxation observed in toluene were suggested by Dr. J. A. Pople (National Physical Laboratory), Prof. H. C. Longuet-Higgins (Cambridge) and Dr. N. Sheppard (Cambridge). Some recent measurements on ultrasonics in gases were discussed by Mr. J. D. Lambert (Oxford), Dr. A. MacColl (University College, London) and Mr. T. L. Cottrell (Imperial Chemical Industries, Ltd.).

Finally, two new techniques giving information about relaxation times in energy transfer in gases were discussed. Dr. R. W. B. Stephens (Imperial College of Science and Technology, London) described an apparatus in which interrupted infra-red radiation is absorbed by a gas, and the vibrational energy taken up reappears as translational energy in the form of a pressure rise out of phase with the radiation input. The lag in phase depends on the relaxation time and this has been used to study relaxations in carbon monoxide and carbon dioxide.

Dr. A. G. Gaydon (Imperial College of Science and Technology, London) described an adaptation of the sodium-line reversal technique to the measurement of temperature changes in shock waves in gases showing relaxation. This procedure is probably capable of giving relaxation times at high temperatures more accurately than the interferometric study of density changes.

J. C. McCOUBREY

PLANT MORPHOGENESIS

A SYMPOSIUM on "Experimental Approaches to the Problems of Growth and Form in Plants", arranged by the Experimental Morphology Group of the Linnean Society, was held under the auspices of the Society in London during December 19–20. The symposium attracted a large and representative audience and was, in fact, an unusually interesting and successful occasion. It is probably true to say that this was one of the most varied and comprehensive treatments of plant morphogenesis that has been witnessed in Great Britain in recent years. (So considerable was the audience that the meetings had to be transferred to the rooms of the Geological Society.)

The papers presented at the symposium, some twenty in all, covered a wide range and explored the many aspects of morphogenesis by diverse experimental techniques. This wide spread of interest brought its own difficulties—the usual one on such occasions—that there was, unfortunately, all too little time for discussions.

It had been arranged that some of the longer contributions should be in the nature of general surveys. The opening paper, by Prof. C. W. Wardlaw, was of this kind, and dealt with observational, experimental and analytical methods which have contributed to our understanding of plant morphogenesis; Prof. L. J. Audus discussed both in general terms and with citation of specific examples the mechanism of correlation in plant development; Prof. J. Heslop Harrison similarly dealt in broad outline and in some detail with certain concepts of the action of growth substances in flower morphogenesis; and Dr. P. W. Brian gave an interesting account of morphogenetic situations in which the gibberellic acids were more or less directly involved. Also in the category of more general surveys, Dr. L. C. Luckwell outlined the very considerable scope for work on the factors controlling the growth and forms of fruits, and outlined some of the contemporary studies and achievements.

Among the many investigations of growth and form presented to the meeting, it was interesting to note that the algae (Dr. E. M. Burrows), fungi (Dr. N. Robertson) and mosses (Dr. J. H. Tallis; Dr. E. Lodge) had attracted their share of attention, as, indeed, they well might. Perhaps the most evident omissions were papers dealing with the contributions of tissue- and organ-culture techniques to morphogenesis; little was said about the action of physical factors in morphogenesis and, with some exceptions, genetical factors tended, on the whole, to be taken for granted and treated, as it were, in passing.

Considerations of space do not admit of detailed reference being made to the many papers contributed to the symposium. A high standard of interest was certainly maintained throughout. In the circumstances, the scope and vitality of contemporary work on the many aspects of morphogenesis in British universities and horticultural institutes may perhaps be indicated by citing the titles to which reference has not already been made: effects of environment on leaf development in *Impatiens parviflora* (Dr. A. P. Hughes); some factors affecting the production of stolons in the potato (Dr. A. Booth); the study of apical development in relation to etiolation (Dr. G. R. Lane and Mr. R. D. Butler); the experimental investigation of the pteridophyte life-cycle (Mr. P. R. Bell); changes in leaf arrangement in individual fern apices (Dr. E. G. Cutter); some growth responses to gibberellic acid (Dr. M. Y. Stant); the effect of very long days on the flowering of winter rye (Prof. F. G. Gregory and Dr. Olive N. Purvis); some effects of environment and hormone treatment on reproductive morphology in *Chrysanthemum* (Dr. W. W. Schwabe); floral morphogenesis in *Primula bulleyana* (Dr. F. Cusick); problems of juvenility and flowering in trees (Prof. P. F. Wareing); temperature-induced meristic and other variation in *Cannabis* (Dr. Y. Heslop Harrison and Miss I. Woods).

A complete number of the Linnean Society's *Journal of Botany* is being devoted to publishing the contributions to the symposium, and the papers are already in the hands of the printers. As it is anticipated that there will be a larger demand than usual for this number of the *Journal*, all those who are not Fellows or Associates of the Society, and who wish to have copies, should write for particulars, as soon as possible, to the General Secretary of the Linnean Society, Burlington House, Piccadilly, London, W.1. Early publication will not only make available a fund of valuable contemporary information but is also likely to provide a useful stimulus to further effort in this fascinating and central field of botanical science.

The officers of the Linnean Society are to be thanked for rendering a signal service by sponsoring the meeting. Thanks are also due to Prof. Heslop Harrison and Mr. P. R. Bell, who were responsible for the inception and arrangement of the symposium, and they are to be congratulated on the success of its meetings. C. W. WARDLAW

SCIENTIFIC COUNCIL FOR AFRICA SOUTH OF THE SAHARA

THE report* of the Secretary-General to the ninth meeting of the Scientific Council for Africa South of the Sahara, held at Accra during August 7–16, which surveys the activities of the Council during the year, is supported by lists of forthcoming meetings and of publications in 1958, and by particulars of the conclusions and recommendations of the Conference. Among the general conclusions of the Conference may be noted the Council's view that the Foundation for Mutual Assistance in Africa South of the Sahara will become one of the most active elements of the Commission for Technical Co-operation in Africa, and the emphasis placed on the very careful examination of each request for technical assistance in Africa in order to determine the best way of meeting it effectively. The Foundation now incorporates the earlier organization for the exchange of scientists and technicians.

Concern is again expressed at the accelerated rhythm of useless destruction and inconsiderate exploitation of Nature and natural resources, and the attention of Governments is directed to the need for agreement at inter-African level in the protection of this common economic and scientific inheritance. Such protection must be based essentially on a policy of rational utilization, and the Council recommended the urgent establishment of a committee for the conservation of Nature and natural resources in all African territories where no such organization exists; the appointment of an inter-African scientific correspondent responsible for ensuring liaison between the various territorial committees, to follow the evolution of common problems, and to keep the Commission and the Council informed; and the preparation of a charter for the protection of natural resources applicable to all territories in the African continent. The protection visualized by the Council comprises the management and supervision of areas which are properly exploited so that the amount of products consumed is commensurate with real social and economic needs and the possible renewal of resources; the establishment of adequate protective areas as indispensable reserves of flora and fauna; and the establishment of national parks and special reserves to protect certain resources of particular interest or value, which would otherwise become extinct or be rapidly exhausted.

Some change in the functions and activities of the Inter-African Bureau of Soils is recommended to the Third Inter-African Soils Conference to meet in the autumn of 1959, and the establishment of a panel of correspondents is recommended, as a matter of urgency, to cover physical oceanography, marine biology, the technology of fishing and the treatment of sea products. An inter-African scientific correspondent for oceanography and sea fisheries should be appointed to activate this Panel. Subject to confirmation by the Commission, the Council decided to call a meeting of specialists in 1959 to study research and related work in Africa on viruses and rickettsiæ common to man and animals, with particular reference to modes of transmission, host species and reservoirs and methods of control. The Council also recommended that the Commission should give closer consideration to the economic aspects of the technical problems with which it is dealing and that the Commission should undertake comparative studies of limited subjects of economic and financial interest, for example, the effect of demographic changes on economic development, and comparative studies of methods applied to encourage private investment and of methods for the stabilization of prices of agricultural products.

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* Scientific Council for Africa South of the Sahara. Publication No. 32: Ninth Meeting of the Scientific Council, Accra, 1958. Pp. 173. (London: Secretariat, C.C.T.A./C.S.A., 1958.)

The most important development during the year, in respect of the Commission for Technical Co-operation in Africa, stressed in the Secretary-General's report, is the establishment of the Foundation for Mutual Assistance in Africa South of the Sahara. This Foundation will cover the provision of experts, advisers or the technical advice of specialized bodies; the provision of training facilities, for example, by organizing training centres in Africa of interest to several African countries; and the offer of equipment for research and education. However, the proceedings at the ninth meeting of the Scientific Council, the Secretary-General's report, with its survey of activities in soils and agriculture, in veterinary and medical science, in cartography, and in social, technological and economic matters, illustrate even more strongly the important place which the Scientific Council has already come to occupy in the development of Africa South of the Sahara and its inherent advantages in enabling European scientists, institutes and technical departments to continue to play their part in supplying the scientific and technical assistance needed in Africa. Neither the work of the Council nor its opportunities are as yet sufficiently known and the Bulletin, "Science-Afrique", the twelfth number of which appeared in September 1958, is a valuable supplement to this annual report for distributing information both about the Commission and the Council.

THERMAL REACTIONS OF HIGHLY FLUORINATED *CYCLO*HEXADIENES*

By B. GETHING, DR. C. R. PATRICK and PROF. J. C. TATLOW
Chemistry Department, The University, Edgbaston,
Birmingham 15

AND

DR. R. E. BANKS, DR. A. K. BARBOUR and A. E. TIPPING
Research Department, Imperial Smelting Corporation,
Avonmouth

HIGHLY fluorinated *cyclo*hexa-1 : 3 - and -1 : 4-dienes may be prepared from polyfluoro*cyclo*hexanes[1-3], by dehydrofluorination using aqueous alkali[1,2], ion exchange resins (Banks, R. E., Bevan, W. I., and Musgrave, W. K. R., unpublished results) or pyrolysis (Banks, R. E., and Tipping, A. E., unpublished results). The first aim of the work reported here was the conversion of fluoro*cyclo*hexa-1 : 4 -dienes into the more reactive and potentially more useful 1 : 3-diene isomers. Further, it was hoped that the 1 : 3-dienes might be sufficiently unstable with respect to the related fluorobenzenes to make possible new syntheses of aromatic compounds from them.

We now wish to report two new thermal reactions of highly fluorinated *cyclo*hexadienes by which both these objectives have been achieved. When these compounds are heated to temperatures in the range 250–600° C., in the absence of a reactive metal surface, isomerization is the predominant reaction. When the dienes are heated to similar temperatures in the presence of various metals, defluorination is the predominant reaction and fluorobenzenes are formed. These reactions may be carried out in a flow system or batchwise in pressure vessels.

We have found that both octafluoro*cyclo*hexa-1 : 3-diene and octafluoro*cyclo*hexa-1 : 4-diene are converted into a mixture of the dienes by passage through a tube heated to temperatures in the range 400–600° C. The best results were obtained using an unpacked nickel tube which had been 'aged' by carrying out several preliminary experiments, so as to avoid defluorination by the clean metal surface. The contact times required to bring about this and other isomerizations are of the order of 5 min. or less. The compositions of the mixtures produced are not greatly dependent on either temperature or contact times, and it is probable that they are close to equilibrium compositions. It is reasonable to suppose that the equilibrium constant for an isomerization will have only a small temperature coefficient, since the energy differences between the isomers should presumably be of the same order as those between conjugated and non-conjugated hydrocarbon dienes, and these would appear to be small. This is suggested by a comparison of tabulated values of heats of hydrogenation of olefins[4].

This isomerization reaction is general for highly fluorinated dienes. Thus, treatment of 1H-heptafluoro*cyclo*hexa-1 : 3-diene[1,2] at 260° C. yielded a mixture of the starting material, 1H-heptafluoro*cyclo*hexa-1 : 4-diene and 2H-heptafluoro*cyclo*hexa-1 : 3-

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* British Patent Application Nos. 29173/58 and 29174/58 (September 11, 1958).

diene. Also, during additions of fluorine to certain 1 : 3-dienes for structure determination purposes, products have been obtained[2,5] which can arise only by a prior isomerization of the diene by a process of this type.

In the course of these investigations some evidence was obtained for a disproportionation reaction of fluorodienes since, for example, under certain conditions some decafluoro*cyclo*hexene together with hexafluorobenzene were formed from octafluoro*cyclo*hexa-1 : 3-diene. This aspect was not pursued, however, since a more interesting effect was observed if fluoro*cyclo*hexadienes were passed over clean metal surfaces at 400–600° C. Defluorination occurred readily, and aromatic fluoro-compounds were formed in good yield. These defluorination reactions are best brought about using tubes packed with nickel or iron gauze or turnings to increase the area of metal surface available, and with contact times of 2–5 min. As a consequence of the defluorination, the metal becomes coated with an impervious layer of fluoride and is deactivated, but the fluoride coating may be removed by the passage of hydrogen at temperatures greater than about 300° C.

Both isomers of octafluoro*cyclo*hexadiene were converted in good yield to hexafluorobenzene[6]. Small amounts of decafluoro*cyclo*hexene were also formed under certain conditions, apparently from the disproportionation reaction mentioned above. 1H-Heptafluoro*cyclo*hexa-1 : 3-diene gave, on defluorination, a mixture of pentafluorobenzene[7] and hexafluorobenzene, the last in smaller amounts, formed perhaps by dehydrofluorination of the isomeric diene with a >CHF group. 1H : 5H-Hexafluoro*cyclo*hexa-1 : 4-diene[5] was defluorinated to give chiefly 1 : 2 : 3 : 5-tetrafluorobenzene[8], together with some pentafluorobenzene. The high yields in which these benzenes are obtained, and the ease of preparation of some of the dienes, particularly the octafluorodienes, make this defluorination process a valuable method for the preparation of polyfluorobenzenes.

These reactions are novel in the field of organic fluorine chemistry. So far as we are aware, isomerizations of perfluoro-dienes have not been reported before and controlled defluorination processes of the type described here are rare, and have not been used synthetically.

Reactions were carried out by passing the diene through a nickel tube (1 in. diameter, 2 ft. 6 in. long) in a stream of nitrogen (2 l./hr.). The central portion of the tube was heated in an electric furnace. Temperatures were measured by a thermocouple placed on the outer wall of the tube in the centre of the heated zone. The products were condensed in a trap immersed in liquid air, and were analysed using gas chromatography. The components were separated by preparative-scale gas chromatography[9] and were identified by comparison of their infra-red spectra with those of authentic samples. For the isomerization reactions the best results were obtained after 'ageing' of the tube, that is, after several runs had been carried out.

Isomerizations. (1) Octafluoro*cyclo*hexa-1 : 4-diene (3·2 gm.) was passed through an 'aged' nickel tube heated to 450°. The product (2·9 gm.) was shown by analytical gas chromatography to contain 40 per cent of the *cyclo*hexa-1 : 3-diene.

(2) 1H-Heptafluoro*cyclo*hexa-1 : 3-diene (3·2 gm.) was passed through an 'aged' nickel tube heated to 260°. The products (3·1 gm.) were separated by gas chromatography to give 1H-heptafluoro*cyclo*hexa-1 : 4-diene (0·94 gm.), 1H-heptafluoro*cyclo*hexa-1 : 3-diene (1·28 gm.), and 2H-heptafluoro*cyclo*hexa-1 : 3-diene (0·21 gm.).

Defluorinations. In the following experiments the nickel tube was packed with Dixon gauze rings (1/16 in. × 1/16 in.). The metal became coated with metal fluoride during the defluorination and was regenerated between runs by passage of hydrogen at a rate of 5–10 l./hr. for about ½–1 hr. The effluent gas stream contained hydrogen fluoride. Excess hydrogen was then removed by nitrogen before the diene addition commenced.

(1) A mixture of octafluoro*cyclo*hexa-1 : 3- and 1 : 4-dienes (19 gm.) was passed in 3-ml. aliquots through the nickel tube packed with nickel Dixon gauze rings heated to 630–660°. After passage of each aliquot the metal was regenerated by hydrogen (5 l./hr. for 15 min.). The products were combined and separated by gas chromatography to give hexafluorobenzene (12·8 gm.) and decafluoro*cyclo*hexene (0·8 gm.).

(2) 1H : 5H-Hexafluoro*cyclo*hexa-1 : 4-diene (3·2 gm.) was passed through the nickel tube packed with nickel Dixon gauzes. The product (2·2 gm.) was separated by gas chromatography to give a mixture (1·7 gm.) shown by infra-red spectroscopy to contain 1 : 2 : 3 : 5-tetrafluorobenzene (80 per cent) and pentafluorobenzene (20 per cent). These two compounds cannot be resolved on the gas chromatography column packing used.

(3) 1H-Heptafluoro*cyclo*hexa-1 : 3-diene (3·2 gm.) was passed at 540° through the nickel tube packed with nickel Dixon gauzes. The product (2·0 gm.) was separated by gas chromatography to give hexafluorobenzene (0·64 gm.) and pentafluorobenzene (0·98 gm.).

(4) 1H-Heptafluoro*cyclo*hexa-1 : 3-diene (3·2 gm.) was passed through the nickel tube packed with steel Dixon gauze rings and heated to 570°. Of the product (2·2 gm.), a portion (1·7 gm.) was separated by gas chromatography to give hexafluorobenzene (0·56 gm.) and pentafluorobenzene (1·00 gm.).

(5) Octafluoro*cyclo*hexa-1 : 4-diene (5 gm.) was heated at 540° for 2¾ hr. in a nickel autoclave packed with mild steel tubes. The product (4·2 gm.) contained by weight hexafluorobenzene (40 per cent), decafluoro*cyclo*hexene (1 per cent), octafluoro*cyclo*hexa-1 : 3-diene (13 per cent) and starting material (46 per cent).

(6) Octafluoro*cyclo*hexa-1 : 4-diene (21 gm.) was passed at the rate of 12 gm. per hr. through a mild steel tube heated to 500°. The product (17·2 gm.) contained by weight, hexafluorobenzene (55 per cent), decafluoro*cyclo*hexene (6 per cent), octafluoro*cyclo*hexa-1 : 3-diene (12 per cent) and starting material (27 per cent).

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A NEW GENERAL ROUTE TO AROMATIC FLUOROCARBONS*

By B. GETHING, Dr. C. R. PATRICK, Prof. M. STACEY, F.R.S., and
Prof. J. C. TATLOW
Chemistry Department, The University, Birmingham

IN the preceding article[1] it is shown that highly fluorinated *cyclo*hexadienes may be defluorinated by nickel or iron at high temperatures to give polyfluorobenzenes. It seemed possible that the substantially lower stability, under these reaction conditions of the alicyclic relative to the aromatic systems, was not confined to di-olefins. Accordingly, we have investigated fluoro*cyclo*hexenes (Coe, P. L., Patrick, C. R., and Tatlow, J. C., unpublished work) and shown that fluorobenzenes may be obtained from them in good yield. This communication describes the further extension of the defluorination reaction to saturated alicyclic fluorocarbons. Again, defluorination proceeded without difficulty, and we have made perfluorotoluene from perfluoromethyl*cyclo*hexane, perfluoroethylbenzene from perfluoroethyl*cyclo*hexane, perfluoro-*p*-xylene from perfluoro-1 : 4-dimethyl*cyclo*hexane, perfluorodiphenyl from perfluorodi*cyclo*hexyl, and perfluoronaphthalene from perfluorodecalin. Perfluorotoluene has been prepared before[2] in small yield by the addition of fluorine to trifluoromethylpentachlorobenzene followed by dechlorination, and perfluorodiphenyl has been made recently[3] by an Ullmann reaction on bromopentafluorobenzene.

The method of defluorination consists in passing the fluorocarbon in a stream of nitrogen through a metal tube packed with small pieces of iron gauze, and heated to a temperature in the range 400–600°. There would seem to be no objection to the use of other metal packings; for example, nickel also is effective. The metal fluoride produced in the defluorination process may be reduced to metal by the passage of hydrogen to enable further defluorinations to be carried out. We have used a furnace system much larger than that employed in our earlier work[1], in order to achieve longer contact times and to enable larger quantities of material to be handled.

The new compounds prepared have the properties anticipated and appear to be fairly resistant to simple chemical attack. The detailed exploration of their chemical properties is in progress. Evidence for their identity has been provided by determinations of molecular weight, based on the mass of the parent molecule ion formed on electron impact, using a mass spectrometer, and by their giving ultra-violet and infra-red spectra consistent with their structures. As described before[3], with sulphuric acid, perfluorotoluene gave pentafluorobenzoic acid.

We believe that this new synthetic method which we now describe represents a major contribution to fluoroaromatic chemistry. It provides the first general preparative route to the aromatic fluorocarbon series, and thereby opens up a new field. Only two overall stages are involved, namely, fluorination of a hydrocarbon followed by the defluorination. It also represents the first synthetic use for the saturated fluorocarbons, no controlled chemical reactions of which have been known hitherto. The process can probably be extended to cover the preparation of hydrogen-containing aromatic fluorides, as is the case (ref. 1, and Coe, P. L., Patrick, C. R., and Tatlow, J. C., unpublished work) with fluoro*cyclo*hexenes and hexadienes.

Alicyclic Fluorocarbons. These were prepared by the vapour-phase fluorination of toluene, ethyl benzene, *p*-xylene, diphenyl, and decalin, respectively, with cobaltic fluoride[5].

Defluorinations. The sample of material to be defluorinated was allowed to distil into a stream of nitrogen, and was carried through a nickel tube (diameter 2½ in., length 4 ft.), packed with small pieces of iron gauze and heated over most of its length by an electric furnace. Over the central portion (about 2 ft. in length) the temperature was sensibly constant to within about 5° C. during any experiment. The rate of flow of nitrogen measured, using a calibrated 'Rotameter' flowmeter, was maintained constant during each experiment. The reaction products were collected in a trap immersed in liquid air. After each reaction the metal fluoride produced by the defluorination process was reduced to metal by passage of hydrogen at temperatures between 300° and 600° C., enabling further reactions to be carried out. Excess hydrogen was then removed in the nitrogen stream.

Perfluorotoluene. Perfluoromethyl*cyclo*hexane (17·8 gm.) was passed through the reactor at 500° in a stream of nitrogen (2 l./hr.). The product (11·6 gm.) was separated by gas chromatography[6] to give perfluorotoluene (3 gm.), boiling point 102–3°, n_D^{20} 1·3680 (found: C, 35·5; F, 64·1; calculated for C_7F_8: C, 35·6; F, 64·4 per cent). Mass spectrometry: principal mass peaks: 236, C_7F_8; 217, C_7F_7; 167, C_6F_5; 148, C_6F_4; 129, C_6F_3; 69, CF_3. Perfluorotoluene (3·2 gm.) and concentrated sulphuric acid (2·5 gm.) were heated at 160° in a sealed tube for 12 hr. The product was poured into iced water, the solution made alkaline, filtered and extracted with ether. Acidification of the aqueous solution precipitated most of the product; the rest was isolated by continuous extraction with ether. Recrystallization from toluene – light petroleum (boiling point 60–80°) gave pentafluorobenzoic acid (1·8 gm.), melting point 104–105°, undepressed in admixture with an authentic specimen[3].

Perfluoroethylbenzene. Perfluoroethyl*cyclo*hexane (9·1 gm.) was passed in a stream of nitrogen (6 l./hr.) through the reactor at 490° and gave a product (4·9 gm.) which was separated by gas chromatography to give perfluoroethylbenzene (1·5 gm.), boiling point 114–115°, n_D^{20} 1·3620 (found: C, 33·2; F, 66·0; C_8F_{10} requires C, 33·6; F, 66·4 per cent). Mass spectrometry: principal mass peaks: 286, C_8F_{10}; 267, C_8F_9; 217, C_7F_7; 167, C_6F_5.

Perfluoro-p-*xylene.* Perfluoro-1 : 4-dimethyl*cyclo*hexane (9·1 gm.) was passed through the reactor at

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* British Patent Application No. 35520/58 (November 5, 1958).

660° in a stream of nitrogen (2 l./hr.) and gave a product (5·9 gm.) which was separated by gas chromatography to give perfluoro-*p*-xylene (2·9 gm.), boiling point 117–118°, n_D^{19} 1·3610 (found: C, 33·9; F, 66·3 per cent). Mass spectrometry: principal mass peaks: 286, C_8F_{10}; 267, C_8F_9; 217, C_7F_7.

Perfluorodiphenyl. Perfluorodi*cyclo*hexyl (5·2 gm.) was passed through the reactor at 390° in a stream of nitrogen (2 l./hr.). The product (0·8 gm.) was recrystallized from benzene to give perfluorodiphenyl (0·5 gm.), melting point 67–69°. The value cited in the literature[3] was 70°; a mixed melting point of the two samples showed no depression, and their infra-red spectra were identical.

Perfluoronaphthalene. Perfluorodecalin (19·2 gm.) was passed in a stream of nitrogen (2 l./hr.) through the reactor at 500°, and gave a product which contained a solid. After being filtered off and recrystallized from benzene, this gave perfluoronaphthalene (5·8 gm.), melting point 86–87° (found: C, 44·3; F, 55·3 per cent; *M* (ebullioscopically in benzene) 260 ± 10. $C_{10}F_8$ requires C, 44·1; F, 55·9 per cent; *M*, 272).

We thank Dr. J. R. Majer for the mass spectrometric results.

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FEEDBACK THEORY OF HYDROGEN OVERVOLTAGE

By J. F. CHITTUM

California Research Corporation, La Habra, California

INDICATIONS have been found that hydrogen overvoltage is related to hydrogen adsorption on cathodes[1]. This evidence leads me to suggest a feedback theory of hydrogen overvoltage based on the hypothesis that a metallic-bonded hydrogen – metal complex exists on the surface where hydrogen is evolved. This complex H(*M*) raises electron energy-levels on the metal side of a cathode[2], as shown in Fig. 1. (Where hydrogen is metallically bonded to the metal and φ of hydrogen as a metal is less than φ of the metal, the φ of the complex should be less than φ of the metal.) The hydrogen evolution reaction will not proceed at equilibrium potential unless the complex is maintained on most of the surface to make a pure electrode, and a zero current overvoltage is required to maintain the layer of complex.

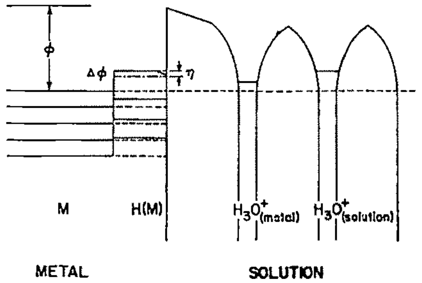

Fig. 1. Electronic energy levels at a cathode where the hydrogen evolution reaction occurs

Experimental data on hydrogen adsorption energy for hydrogen-covered metals are few. Beek[3] reports 18–20 kcal./mole for rhodium (and presumably platinum, palladium, etc.), and 10–13 kcal./mole for nickel, iron, tungsten and tantalum (and presumably many other metals). Estimated hydrogen adsorption energies for mercury, thallium, and lead covered with hydrogen are 6–8 kcal./mole. These energies are much lower for covered metals than for clean metals[3], and the latter energies are even partly reversed; that is, greater for tungsten and tantalum than for platinum and palladium. Decreased hydrogen adsorption energy with increased surface coverage may be due to residual covalent metallic bonding by *s* electrons of hydrogen and metal atoms after the combined *s*, *p*, *d* bonding[4] is used up. At least if the barrier-lowering hydrogen adsorption energy for covered metals is higher, overvoltage is lower, and overvoltage mechanisms can thereby be divided into three groups.

Steps in three hydrogen evolution reaction mechanisms for metal groups, *F*, *I*, and *S*, are shown in Table 1 for acid solutions. The *F* metals include mercury, thallium and lead with feeble hydrogen adsorption on covered surfaces. The *I* metals include cadmium to nickel, with intermediate hydrogen adsorption energies on covered surfaces. The *S* metals include platinum, palladium, rhodium, etc., with the strongest adsorption on covered surfaces. In Table 1, *x* under *F*, *I*, or *S* indicates a hydrogen evolution reaction step for metals in the group and *X* indicates the rate-determining step for each mechanism. Steps 1, 3 and 5 are so rapid that they do not influence

Table 1. OUTLINE OF STEPS IN THE FEEDBACK THEORY OF HYDROGEN OVERVOLTAGE IN ACID SOLUTIONS

Step No.	Steps in the hydrogen evolution reaction	Metal: *F*	*I*	*S*
1	$H_3O^+ (s) = H_3O^+ (M)$	*x*	*x*	*x*
2*a*	$H_3O^+ (M) + e^- (M) = H(M) + H_2O$	*X*		
2*b**	$\frac{1}{2} H_2(M) = H(M)$		*X*	*x*
3	$H_3O^+ (M) + e^- (H(M)) = H(M) + H_2O$	*x*	*x*	*x*
4	$2H(M) = H_2(M)$	*x*	*x*	*X*
5	$\frac{1}{2}H_2(M) = \frac{1}{2} H_2 (f)$	*x*	*x*	*x*

* Essential step in the feedback theory.

(*s*), in solution; (*M*), on or from metal; (H(*M*)), from chemisorbed hydrogen; (*f*), free; *x*, step in hydrogen evolution reaction; *X*, slow step in the reaction.

F metals: mercury, thallium and lead.

I metals: cadmium, beryllium, neodymium, aluminium, copper, gallium, iron, silver, etc.

S metals: platinum, palladium and rhodium.

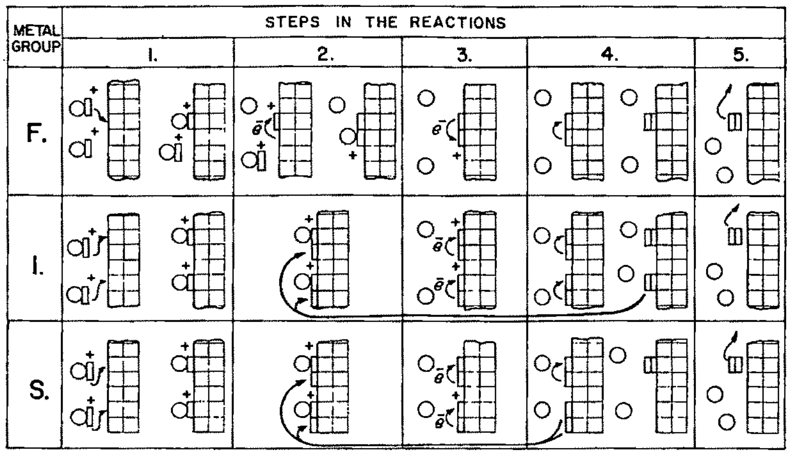

Fig. 2. Mechanisms of feedback theory for hydrogen evolution reactions. □, Metal atom; ○, water molecule; ▯, hydrogen atom; ▯+, hydrogen ion; ◫, hydrogen molecule; *e*, electron

overall rates. Steps 2*a*, 2*b*, and 4 only are sensitive to the energy of hydrogen bonding on covered surfaces.

Two competitive steps 2*a* and 2*b* are available for forming the complex: (*a*) step 2*a* occurs on *F* metals because hydrogen adsorption by 2*b* is slower, and (*b*) step 2*b*, the feedback part of the reaction, occurs on *I* and *S* metals at a rate that obviously depends on hydrogen adsorption energy. Step 2*b* is slower than step 2*a* for *F* metals; it is faster than step 2*a* for *I* metals, although slow enough to be rate determining; and it is so fast for *S* metals that it is not rate determining. Transitions in mechanisms may occur, so that *S* metals can act like *I* metals if the hydrogen adsorption energy decreases further. Step 2*b* is the reverse of step 4. This feedback then has the effect with *S* metals that only half the complex, produced in steps 2*b* and 3, reacts in step 4. Also, groups *I* and *S* differ in that, for *I* metals, step 2*b* is slower than step 4 so that step 2*b* must rebuild sufficient complex to maintain the current density; for *S* metals, step 4 is slower than step 2*b* and so step 4 is rate determining. Feedback differences are shown in Fig. 2 for areas initially deficient in the complex.

Significant experimental results about hydrogen evolution reactions are listed below with explanations from the feedback theory.

(1) *General observations.*

(*a*) Platinized platinum or any highly spongy metal has a low overvoltage because the spongy metals offer an enormous ratio of actual to measured surface area for combination of hydrogen.

(*b*) The hydrogen adsorption poisoning of metals results in increased overvoltage[5] because poisoning decreases the hydrogen adsorption energy.

(*c*) Hydrogen overvoltage increases with time (linearly for *F* metals, erratically for others)[6]. For *F* metals, build-up of the complex and charging of the condenser by step 2*a* should control this increase. For *I* and *S* metals, hydrogen adsorption energy decreases as surface coverage increases.

(*d*) Overvoltage changes with *p*H and the nature of the solvent[7] because hydrogen adsorption energy changes, and overvoltage decreases with increase in pressure for *I* metals[8] because rate of hydrogen adsorption increases. It is independent of pressure for *F* metals[9] because molecular hydrogen does not enter into the slow step.

(2) *The Tafel equation*, $\eta = A + B \log i$, *or* $i = i_0 \exp(\alpha VF/RT)$.

(*a*) Constant *A* is related to hydrogen adsorption because the rate of complex formation increases with the energy of hydrogen adsorption on covered metals.

(*b*) $\alpha = 2{\cdot}0$ and $B = 0{\cdot}029$ for *S* metals, whereas $\alpha = \frac{1}{2}$ and $B = 0{\cdot}114$ for other metals[10], because the slow step in the hydrogen evolution reaction on *S* metals is $2H(M) = H_2(M)$, and two reaction units form a unit product; whereas the slow step on *I* metals is $\frac{1}{2}H_2(M) = H(M)$, and half a reaction unit forms a unit product.

(*c*) i_0 for metals is a straight-line function[11] of φ because Δφ must increase with φ.

(*d*) At high current densities, polarization curves may show breaks indicating an increase in *B* in the Tafel equation up to that shown by *I* metals[12]. Breaks occur for some *S* metals because of decreased hydrogen adsorption energy upon more complete coverage, and for special metals (tungsten, tantalum, chromium and silver) because low current density polarization may be H controlled by hydrogen diffusion[13].

(3) *Hydrogen – deuterium separation.*

Hydrogen – deuterium separation factors divide metals into two groups: (1) *F* metals and possibly border-line metals which have factors about 3, and (2) other metals which have factors[14] of about 6. This division may occur because the activation energy for the reaction:

$$D + H_2O = HDO + H$$

is such as to give a separation factor of about 3 for a single chance of an exchange of *F* metals. The feedback step, 2*b*, for *I* and *S* metals would about double the chance of an exchange and double the factor.

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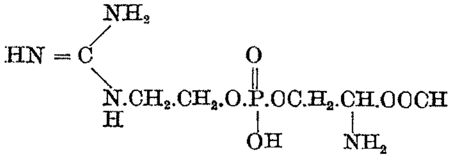
BIOCHEMISTRY OF LOMBRICINE

Occurrence of D-Serine in Lombricine

LOMBRICINE (guanidinoethyl seryl* phosphate) was isolated from earthworms (*Lumbricus terrestris*) by Thoai and Robin[1], and on the basis of paper chromatographic identification of the products of acid hydrolysis the following structure was suggested :



This structure has been confirmed by unequivocal synthetic routes using DL- and L-serine (Beatty and Magrath, following communication). For obvious reasons, it was assumed that the L-enantiomorph was present in the natural product ; but comparison with the synthetic product indicated that this was not the case (following communication). It has now been found that the D-isomer is actually present.

A sample of natural lombricine[2] (580 mgm.) was hydrolysed in a sealed tube in 6 *N* sulphuric acid at 110° C. for 24 hr. The serine present in the hydrolysate was isolated using ion-exchange and paper chromatography to give a final yield of 42 mgm. This material was free from guanidinoethyl phosphate and other hydrolysis products as shown by paper chromatography, using appropriate solvent systems and sprays. Recrystallization from aqueous ethanol yielded crystals ($[\alpha]_D = + 7{\cdot}40°$ in water ; melted with decomp. at 217°, uncorr.) which were identical in chromatographic behaviour in a number of solvent systems with D-serine.

A sample of the crystalline material was examined for its ability to function as a substrate for a crude preparation of sheep kidney D-amino-acid oxidase[3]. An authentic sample of L-serine was not oxidized by this preparation. In the case of the isolated material the amount tested (3·6 mgm.) yielded an oxygen uptake (over 45 min.) identical with that of an equivalent amount of authentic D-serine. The D-amino-acid oxidase was without effect on natural lombricine, synthetic DL-lombricine and synthetic DL-aminoethyl seryl phosphodiester[4].

Initial attempts to use an unfractionated hydrochloric acid hydrolysate product of lombricine as substrate for the enzyme failed because of the inhibitory quality of the hydrolysate. Whether this was due to some product(s) of hydrolysis or to some accidental contaminant is not known, but the result does cast doubt on the allocation of an L-configuration to the seryl moiety of aminoethyl seryl phosphodiester isolated from turtle muscle[5]. The evidence for this rests solely on the inability of a D-amino-acid oxidase preparation to oxidize the serine component of an unfractionated snake venom hydrolysate of the compound. If, as has been suggested[2], the aminoethyl seryl diester isolated from earthworms is the biological precursor of lombricine, it follows from the present results that, in the earthworm at least, the serine moiety of aminoethyl seryl diester would have a D-configuration.

The few claims for the presence of D-amino-acids in animal tissues have not met with general acceptance[6-8]. The configuration about the α-carbon atom of the 'alanine' moiety of octopine has been considered by some to be D-[7,8], but this conclusion seems unwarranted on the basis of the evidence available[9]. This report, therefore, constitutes the first occasion on which a D-amino-acid has been unequivocally shown to exist in animal tissue.

The presence of D-serine in lombricine suggests that this isomer may also be present in other compounds (for example, phospholipids and proteins) in the earthworm and, indeed, that it may not be the only D-amino-acid which occurs in this creature. It is hoped that work at present in progress will shed some light on these possibilities. The full report of this will be published elsewhere.

IVA M. BEATTY
D. I. MAGRATH
A. H. ENNOR

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* In this and the following communication the term 'seryl' is used for convenience and refers to the '2-amino-2-carboxyethyl' group.

Synthesis of DL- and L-Lombricine

ON evidence based mainly on the paper chromatographic identification of the products of acid hydrolysis, it was concluded that lombricine was a mixed phosphodiester of serine and guanidinoethanol[1]. The amount of material isolated was small, and the configuration of the serine moiety was not investigated.

We wish to report the synthesis of DL- and L-lombricine by a route which confirms the structure allocated[1] and further indicates that the seryl residue in natural lombricine has the D-configuration. DL- and L-seryl aminoethyl phosphates were synthesized from the corresponding protected serine derivatives and N-carbobenzoxyethanolamine by a 'staggered' reaction with monophenylphosphorodichloridate, according to the method of Jones and Lipkin[2]. Subsequent reaction with O-methyl *iso*urea in aqueous solution at approximately *p*H 11 resulted in selective conversion of the aminoethyl residue in these compounds to a guanidinoethyl residue, giving DL- and L-lombricine in more than 70 per cent yield. Preliminary attempts to protect the α-amino group of the seryl moiety during the reaction with O-methyl *iso*urea, by forming a complex with copper (cf., for example, the preparation of arginine from ornithine[3]), led to extensive degradation of the molecule. Lombricine was found to be similarly unstable in the presence of copper, and the mechanism of the degradation is being investigated.

Both synthetic products crystallized from aqueous alcohol as colourless rods, the DL- melting at 216° C. (decomp.) and the L- at 226° (decomp.) ; natural lombricine[4], 224° (decomp.) (Thoai and Robin[1] give 223–24°). All samples showed discoloration before melting and the melting point varied appreciably according to the rate of heating and state of subdivision. Analysis : calc. for $C_6H_{15}O_6N_4P$: C, 26·6 ; H, 5·5 ; N, 20·8 ; P, 11·5 per cent ; found : DL- :

C, 26·5; H, 5·5; N, 20·9; P, 11·6; L-: C, 26·6; H, 5·6; N, 20·7; P, 11·6 per cent.

Both the synthetic compounds had R_F values identical with the natural product in a number of solvent systems. Similarly, the acid hydrolysates (6 *N* sulphuric acid, 110°, 8 hr.) of all three gave identical patterns of ninhydrin, α-naphthol-diacetyl[5] and molybdate[6] reacting spots, which corresponded with markers of authentic serine, guanidinoethanol and guanidinoethyl phosphate (synthesized in 84 per cent yield by reaction of ethanolamine phosphate with O-methyl *iso*urea in aqueous alkali).

pK_a values (potentiometric): DL-, 2·19, 8·9; L-, 2·16, 8·93; natural, 2·32, 8·9. The infra-red spectrum (potassium bromide disk) of the L-isomer was identical with that of natural lombricine, but differed significantly from that of the DL-compound.

For the L-isomer, $[\alpha]_D^{23\cdot5} = -13\cdot0$ ($c. = 0\cdot81$ in water), for the natural, $+14\cdot5$ ($c. = 0\cdot93$ in water), indicating a D-configuration in the serine moiety of natural lombricine.

The synthesis of D-lombricine by a route analogous to that described above is in progress. It may also be noted that a product having the expected chromatographic and chemical properties (stability to acid, spray reactions, etc.) of the naturally occurring phosphagen, N-phosphoryllombricine[1,7], has been obtained by reaction of N-phosphoryl O-methyl *iso*urea[8] with seryl aminoethyl phosphate under similar conditions.

Full details of this work will be published elsewhere.

We are indebted to Dr. H. Rosenberg for a sample of natural lombricine, and to Drs. J. E. Fildes, D. Perrin and E. Spinner for microanalyses, *pK* values and infra-red spectra, respectively. Phosphorus analyses were carried out by Mr. B. Thorpe.

IVA M. BEATTY
D. I. MAGRATH

Department of Biochemistry,
John Curtin School of Medical Research,
Australian National University,
Canberra.

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STRUCTURE OF α-KERATIN

By DR. R. D. B. FRASER, T. P. MACRAE and DR. G. E. ROGERS

Division of Protein Chemistry, Wool Research Laboratories, Commonwealth Scientific and Industrial Research Organization, Parkville, N.2, Melbourne

THE examination of thin sections of developing hair[1,2] and fragments of chemically degraded wool[3,4] in the electron microscope has led to the view that α-keratin consists of microfibrils about 60–80 A. in diameter embedded in a matrix rich in sulphur. Confirmation of this structure by direct examination of intact, fully hardened keratin fibres is highly desirable but has been hampered by the difficulty of obtaining suitable sections. Mercer has alluded to a confirmation of this structure[5] but has not reported his findings in detail. We have found that by combining electron microscope observations with parallel studies of low-angle X-ray diffraction and measurements of infra-red dichroism, an elaboration of earlier notions of the molecular organization in α-keratin is possible.

A typical result obtained when reduced keratin fibres are treated with osmium tetroxide and examined in cross-section is shown in Fig. 1, in which fine fibrils about 70 A. in diameter are revealed by the greater concentration of osmium in the surrounding material. This shows at once that the microfibrils and matrix seen in developing hair retain their identity in fully hardened keratin. The nature and perfection of the microfibril packing are found to vary according to the origin of the keratin, being in some cases predominantly near-hexagonal (Fig. 1), while in others there is evidence of the spiral aggregates seen in developing hair[1,2,5].

In the tip of the quill of the North American porcupine and in human hair areas of near-hexagonal packing are interspersed with regions of alternating light and dark bands (Fig. 2). This may indicate the presence of a monoclinic or random layer lattice in which osmium penetrates readily along only one

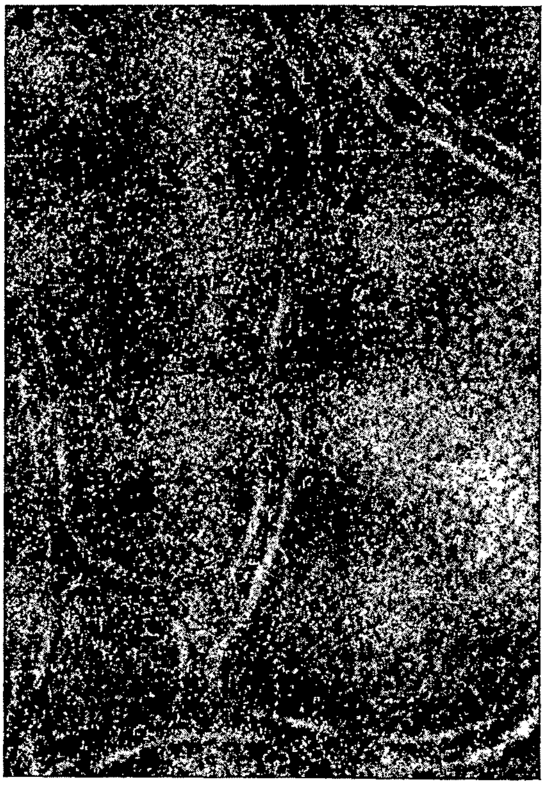

Fig. 1. Cross-section of a Lincoln wool fibre stained with osmium tetroxide after partial reduction of the disulphide linkages. Portions of several cortical cells are separated by dense bands of intercellular cement. (× 200,000)

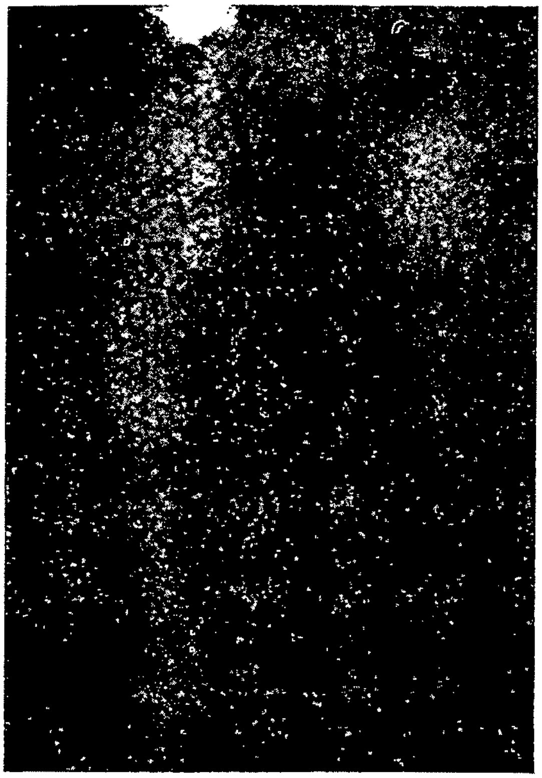

Fig. 2. Cross-section of North American porcupine quill-tip (*Erethizon* sp.) treated as in Fig. 1. The area of near-hexagonal packing of microfibrils adjoins a region where the microfibril-matrix complex appears as alternating light and dark bands. (× 200,000)

crystallographic plane, and would be consistent with the notion that the microfibrils are polarized, either physically or chemically, so that they tend to aggregate in sheets[1,4]. On the other hand, the alternating bands could be due to a hexagonal lattice viewed obliquely in crystallites where the direction of the microfibrils is not accurately perpendicular to the plane of the section. In Merino wool there is a sharp contrast between the orthocortex and paracortex, the microfibril packing is almost entirely near-hexagonal in the paracortex, while in the orthocortex spiral aggregates similar to those seen in developing hair predominate.

The diameter of the microfibrils is difficult to estimate accurately, but appears to be smaller in Merino than in Lincoln wool. Whether this is due to a variation in the extent to which osmium penetrates the microfibril or to a genuine structural difference is uncertain.

The equatorial low-angle X-ray diffraction pattern of α-keratin is complex but is dominated by three maxima which may be interpreted as lattice reflexions, or combinations of lattice reflexions, in which the intensity is determined by both the shape of the microfibril and the difference in scattering power between microfibril and matrix[6]. When wool, hair or quill-tip is treated with osmium tetroxide these reflexions are intensified[7], but an even greater intensification may be obtained by prior reduction of the ($A + B$) fraction of the cystine residues. As the osmium is now known, from the electron micrographs, to be concentrated in the matrix after this treatment, it is likely that the effects are additive, that is to say, the osmium is also preferentially deposited in the matrix in non-reduced fibres. The contrast in this case does not appear to be sufficient, however, to be detected by electron microscopy.

There is a good deal of indirect evidence to suggest that the microfibrils are the entities responsible for the high-angle X-ray diffraction pattern of α-keratin and that the matrix is largely non-crystalline. The present work lends considerable support to this view as the deposition of osmium in the matrix either before or after reduction has virtually no effect on the high-angle pattern. Osmium tetroxide reacts with a rather wide variety of chemical groupings[8] and the preferential deposition of osmium in the matrix even before reduction would be consistent with a less well-organized arrangement of polypeptide chains in this component.

The additional deposition of osmium in the matrix following reduction of the ($A + B$) fraction[9] of the cystine residues suggests that this fraction is concentrated in the matrix. There is a considerable body of chemical evidence which shows that proteins of much higher cystine content than whole wool may be extracted, and the present work supports the view that these originate in the matrix. Further support for this conclusion is obtained from the observation that reduction and labelling of the ($A + B$) cystine with the specific reagents methyl mercury iodide and neohydrin lead to an intensification of the low-angle equatorial reflexions, although this is much less than with osmium.

The spacing of the innermost equatorial reflexion has been suggested previously to be the distance between adjacent layers in spiral aggregates or the 10·0 reflexion of the areas of hexagonal packing[6]. This spacing has now been measured with greater resolution than in previous work and is found to vary with the origin of the keratin as shown in Table 1. It is interesting to note that the spacing in untreated hair is considerably greater than that of quill or wool and may be correlated with the higher cystine content of this material. The small but definite increases observed when keratin fibres are reduced and treated with osmium are also given. The measured spacings in these specimens agree sufficiently well with those determined directly from the electron micrographs to confirm the interpretation given previously.

In simple polymers such as cellulose, crystallinity is a well-defined property which has an important bearing on its physical properties and may be investigated by X-ray diffraction methods, water absorption isotherms and by studying the extent to which the potentially replaceable hydrogen atoms in the structure are replaced by deuterium[10]. The term crystallinity is also used in discussing the properties of keratin, but certain important differences between the significance of the term in the two instances

Table 1

Keratin	Cystine content as percentage total nitrogen	Approximate spacing of innermost equatorial reflexion measured *in racuo* over phosphorus pentoxide	
		Untreated	Reduced and treated with OsO_4
Porcupine quill-tip	6·8	77	82
Lincoln wool	6·8	79	82
Merino wool	7·9	80	87
Human hair	12·0	87	95

emerges from the present work. Although precise measurements are difficult to make, preliminary studies suggest that the fractional increase in the innermost equatorial X-ray spacing when dry keratin fibres are hydrated is about the same as the fractional increase in the fibre diameter. In contrast, the increase in the spacing of the high-angle maximum is only about 5 per cent. It may be concluded, therefore, that the microfibril lattice expands to a greater extent than does the interchain distance within the microfibrils. This suggests either that the hydrophilic side-chains are concentrated in the matrix or that a proportion of the sorption sites located within the microfibrils are inaccessible. A similar conclusion may be drawn from our own[12] and other studies[13] of the hydrogen – deuterium exchange reaction by infra-red spectroscopy, in which the inaccessible peptide linkages have been shown to be concentrated in the oriented regions of the fibre. In addition, we have found that supercontraction in cuprammonium hydroxide, which from X-ray evidence is known to disorganize the internal structure of the microfibrils, increases accessibility, whereas reduction and substitution of the $(A + B)$ fraction of the cystine, now presumed to be concentrated in the matrix, has little effect.

As regards sorption of water, accessibility to deuterium and high-angle X-ray diffraction, the microfibrils appear to behave very much like the crystallites of simpler polymers, but so far as we are aware there is no evidence that they are true crystallites in the crystallographic sense. It is more likely that the asymmetric unit is, in fact, an approximately cylindrical assembly of polypeptide chains about 70 A. in diameter and 200 A. long. At present there does not appear to be any evidence of the arrangement of the polypeptide chains within the asymmetric unit apart from the general conclusion that they occur as groups of compound α-helices[14].

By combining estimates of microfibril diameter obtained from electron micrographs with the spacing of the innermost reflexion of the low-angle equatorial X-ray pattern in untreated keratins, a crude estimate of the relative proportions of microfibril and matrix may be obtained if the packing is assumed to be hexagonal. Estimates obtained in this way vary considerably but suggest that the matrix constitutes between a quarter and a half of the cortex in wool. If the cystine in wool is, in fact, concentrated in the matrix, it should therefore account for about 12–24 per cent of the nitrogen in the matrix protein, assuming equal densities and mean residue weights in the microfibril and matrix. Protein fractions with cystine contents in this range have, in fact, been isolated from wool and probably originate in the matrix[15].

It has been suggested that the bulky side-chains in wool are confined to the amorphous regions[16], and if these are identified with the matrix the upper estimate of its proportion is, in fact, sufficient to accommodate all the cystine, arginine, aspartic and glutamic acids, lysine and tyrosine. However, analyses of the proteins rich in sulphur[15] do not support such a heterogeneous distribution of composition. Evidence has also been obtained which indicates that a significant proportion of the tyrosine is regularly disposed along the length of the microfibril[7], which again does not accord well with this view. As the interchain spacing in the microfibril expands on hydration of the fibre[11] it may be possible for reagents to enter the microfibrils to some extent, in which case the relegation of residues such as tyrosine and lysine to the matrix on the score of their complete accessibility[18] to chemical reagents may not be justified.

In conclusion, the close analogy between globular protein crystals and α-keratin may again be emphasized[17]. In a sense the matrix in α-keratin may be regarded as the counterpart of water of crystallization in globular protein crystals, and this analogy is reinforced by the way in which the intensities of the low-angle X-ray reflexions in both cases vary with the electron density in the spaces between the organized particles, and also by the effect of water-content on the perfection of the X-ray diagram[17]. The replacement of water, or rather dilute protein gel, between the microfibrils by matrix substance is, in fact, observed during biosynthesis of keratin fibres[1,2].

The extent to which the spiral aggregates, formed prior to keratinization, persist in the keratinized fibre varies considerably. The extent of rearrangement to a near-crystalline form is very advanced in quill-tip and virtually complete in the paracortex of Merino wool, whereas in the orthocortex it is only rudimentary. It appears, therefore, that the process of keratinization inhibits the crystallization of the microfibrils at various incomplete stages depending upon the origin of the keratin. The transition from the spiral aggregate to the hexagonal or monoclinic forms is probably related to the greater stability of the latter as the size of the aggregate increases. It may be shown, by the same argument as used by Crick[18] in discussing the formation of compound helices, that stable aggregates of rods with helical grooves, or helical lines of greatest attraction, can be formed in which successive layers lie on the circumferences of concentric cylinders. The contacts between cylinders in the same layers and adjacent layers can be made close to optimum provided the angle of pitch increases by a constant amount in successive layers. The stability, however, decreases rapidly when the pitch angle becomes appreciable, and with further growth a reorganization to a hexagonal form becomes the more stable arrangement.

Thanks are due to Drs. H. Lindley and S. J. Leach for helpful discussions, and to Miss C. M. McKinnon for technical assistance.

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LETTERS TO THE EDITORS

GEOLOGY and GEOPHYSICS

Isotopic Composition of Lead from British Mineral Deposits

It is well established that in many cases there is an approximate relation between the isotopic composition of common lead and the geological age of the lead-bearing mineral deposit, especially when the latter is closely connected with major igneous activity. An isotopic study of several British lead ores (mainly galena) has given preliminary results which clearly indicate the usefulness of the method from a geological point of view. In the case of the British deposits the geological setting is usually well established, while Dunham has reviewed the structural and field evidence for their age[1].

The model chosen for calculation of ages from the isotopic composition is that of Houtermans[2] and Geiss[3], using Patterson's values[4] for the isotopic composition of primeval lead from iron meteorites and modern lead from ocean sediments, together with generally accepted values of uranium and thorium decay constants (see footnote to Table 1).

Isotopic measurements were carried out with a Metropolitan-Vickers *MS*5 solid-source mass spectrometer using the triple-filament volatilization technique on precipitated lead sulphide. The observed abundance ratios were multiplied by the square root of the mass ratio to correct for mass discrimination in the electron multiplier.

Results are presented in Table 1. Within each group, well-located samples have been chosen from a representative area. In most cases the observed ratios lead-206/lead-204, lead-207/lead-204, lead-208/lead-204 agree within experimental error for samples within a given group. The error of each average indicated for these ratios in columns 3, 4 and 5 represents a 95 per cent confidence-level.

The errors given for the average model age in column 6, as well as for the uranium-238/lead-204, thorium-232/uranium-238 ratios, are calculated from the experimental error only. The absolute error is not yet known with certainty, but is thought to lie within similar limits. Absolute age-determinations on uranium minerals from some Cornwall lodes should provide a useful reference point in this connexion.

With the assumptions made in the model, the proved Permo-Carboniferous (Hercynian) ores of south-west England give a model age of 280 ± 30 million years, which is somewhat higher than the average value of 220 million years assumed by Holmes for Hercynian leads[5]. However, in view of the fact that some extension of the Holmes time-scale[6] is indicated by recent potassium–argon work in this laboratory on Hercynian and Caledonian igneous rocks from Great Britain[7], it was decided to retain the higher value for the time being.

There is striking agreement in the model ages and geochemical ratios (columns 7 and 8) between south-west England, the northern Pennines and the Lake District. This suggests that the mineralization in all three areas is connected with Hercynian igneous activity[1,8] and derived from similar source material. The suggestions that: (*a*) the northern Pennine mineralization is Tertiary in age[9]; (*b*) the greater part of the Lake District mineralization is either connected directly with the known Caledonian intrusions[10] or Tertiary in age[9], are not supported by the isotopic data.

Two measured samples from the Lake District have not been included in group 3. These come from the Shap Blue Rock Quarry, Westmorland (kindly supplied by Dr. R. J. Firman), and from the Ruthwaite Lodge Vein, Grisedale, near Patterdale, Westmorland, respectively. The former is possibly associated with the Shap Granite itself[11] and gives a higher model age (370 million years) than any other sample from group 3. In contrast, the Ruthwaite Lodge Vein sample gives a very low model age (80 million years). Furthermore, one sample from Devon has not been included in group 1. This is from the Combe Martin Lode, north Devon, and has a higher model age (360 million years) and, possibly,

Table 1

Group	(1) Locality and donor of specimens	(2) Number of galena samples	(3) $^{206}Pb/^{204}Pb$	(4) $^{207}Pb/^{204}Pb$	(5) $^{208}Pb/^{204}Pb$	(6) Model age (million years)	(7) $^{238}U/^{204}Pb$*	(8) $^{232}Th/^{238}U$*
1	Devon and Cornwall (A. W. G. Kingsbury)	7	18·20 ± 0·03	15·51 ± 0·03	37·97 ± 0·05	280 ± 30	9·10	3·92
2	Northern Pennines (Prof. K. C. Dunham)	4	18·23 ± 0·03	15·53 ± 0·02	38·07 ± 0·06	280 ± 30	9·13	3·95
3	Lake District (A. W. G. Kingsbury)	9	18·25 ± 0·03	15·53 ± 0·02	38·15 ± 0·05	270 ± 30	9·14	3·98
4	Harlech and Aberystwyth Area, North Wales (F. W. Dunning, Dr. P. A. Sabine)	5	18·16 ± 0·03	15·61 ± 0·03	38·14 ± 0·06	440 ± 30	9·32	4·04
5	Abergairn and Ballater Area, Aberdeenshire (Dr. A. McGregor, Prof. F. H. Stewart)	3	17·78 ± 0·04	15·41 ± 0·04	37·56 ± 0·08	470 ± 40	8·96	3·95

* Values extrapolated to the present time. Average errors ± 0·1 and ± 0·05 respectively

Decay constant of ^{238}U = 1·541 × 10^{-10} year^{-1}; decay constant of ^{235}U = 9·72 × 10^{-10} year^{-1}; modern ratio $^{238}U/^{235}U$ = 137·8. Isotopic composition of lead from iron meteorites (ref. 4): 206/204 = 9·50, 207/204 = 10·36, 208/204 = 29·49. Isotopic composition of lead from modern ocean sediments: 206/204 = 18·93, 207/204 = 15·73, 208/204 = 38·80. Age of Earth = 4·50 × 10^9 years.

a different geological history than other deposits of south-west England (Dunning, F. W., personal communication). These samples will be discussed more fully elsewhere.

In contrast, groups 4 and 5 have considerably higher model ages than groups 1, 2 and 3, suggesting that the deposits owe their origin to Caledonian activity. Significant differences in the uranium-238/lead-204 and thorium-232/uranium-238 ratios are also found, implying slightly different geochemical environments.

The galenas of group 5 belong to the small, distinctive mineralization associated with Caledonian granites in the Abergairn and Ballater areas of Aberdeenshire[1]. Three galena samples of group 4 occur in the high-temperature gold–copper deposits of the Harlech Area, north Wales, which Dunham[1] was tempted to assign to the Caledonian epoch, although positive evidence was lacking. The two remaining samples come from typical Plynlimmon localities, some miles east and north-east of Aberystwyth where, significantly, the veins occur in Silurian strata. O. T. Jones[12] had already suggested that in this area some of the vein-fractures were contemporaneous with Caledonian folds.

More isotopic analyses of British and Irish common leads are in progress; detailed results and their bearing on geological problems will be published in due course.

Grateful acknowledgment is made to Dr. A. McGregor, Dr. P. A. Sabine and F. W. Dunning, of H.M. Geological Survey, as well as Prof. K. C. Dunham, Prof. F. H. Stewart and A. W. G. Kingsbury, for donation of the specimens used in this work. The work forms part of the geological age and isotope research programme being carried out in this Department under the general direction of Prof. L. R. Wager and Dr. E. A. Vincent.

S. MOORBATH

Department of Geology and Mineralogy,
University Museum,
Oxford.
Jan. 9.

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Palæomagnetism of Certain Rocks from Newfoundland

DURING the course of a visit to Newfoundland in the summer of 1957, orientated rock samples were collected by members of the Durham University Exploration Society. Pre-Cambrian rocks near St. Johns and the Mississippian Codroy rocks north of Robinson's River were sampled.

The Pre-Cambrian rocks were obtained from two localities, Signal Hill and Blackhead, on the Avalon Peninsula. The collection made on Signal Hill where the beds dip steeply eastwards represented an older horizon than the less-steeply dipping rocks collected from Blackhead, for it is clear from both graded and current bedding that the rocks are not inverted. Lithologically there is no marked difference between the two areas, the sediments at both places consisting of hard, purplish sandstones although the stratigraphical separation may be of the order of 8,500 ft.

Table 1. MEAN DIRECTION OF MAGNETIZATION OF NEWFOUNDLAND SAMPLES

Formation	Declination	Inclination	α	$\varkappa$	N	S	Mean intensity of magnetization
Codroy group	166°	+8°	8·4	38	36	9	$16{\cdot}2 \pm 11{\cdot}4 \times 10^{-6}$
Pre-Cambrian	262	+39	13·3	8	76	19	$14{\cdot}4 \pm 7{\cdot}9 \times 10^{-6}$
Blackhead collection	232	+51	9·9	25	40	10	—
Signal Hill collection	283	+20	11·3	21	36	9	—

α, Radius of the circle of confidence; $\varkappa$, a measure of precision; N, number of measurements; S, number of samples measured.

Table 2. POLE POSITIONS CALCULATED BEFORE AND AFTER 20° ROTATION

Formation	Site	Ancient pole	$d\psi$	$d\chi$	Re-oriented ancient pole
Codroy group	59 W. 48 N.	139 E. 43 N.	4·3	8·5	113 E. 44 N.
Pre-Cambrian	53 W. 47 N.	122 W. 11 N.	9·6	16	136 W. 23 N.
Blackhead collection	53 W. 47 N.	96 W. 5 S.	9·1	13·4	110 W. 10 N.
Signal Hill collection	53 W. 47 N.	142 W. 16 N.	6·2	11·8	163 W. 29 N.

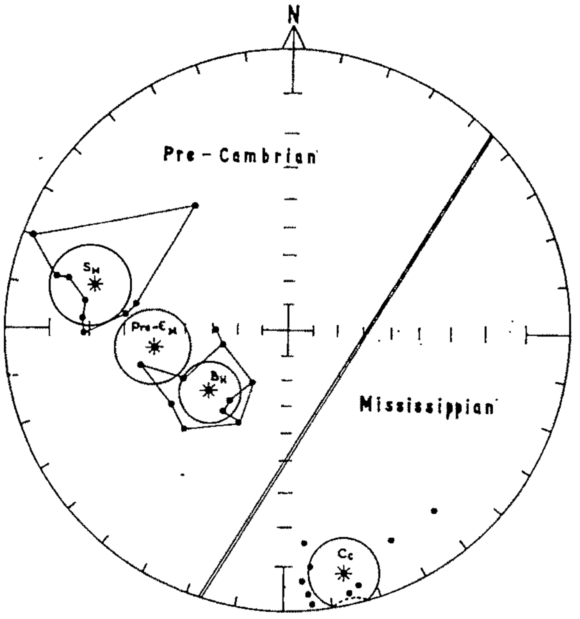
$d\psi$ and $d\chi$, semi-axes of the oval of confidence of the pole positions.

The Mississippian rocks, some 1,200 ft. thick, comprise a lower deltaic series, the Anguille group, overlain by the Codroy group of homogeneous, fine-grained, hard red unfossiliferous sandstones. The beds dip steeply north-west, and their structural and stratigraphical relationships have been studied by Baird.

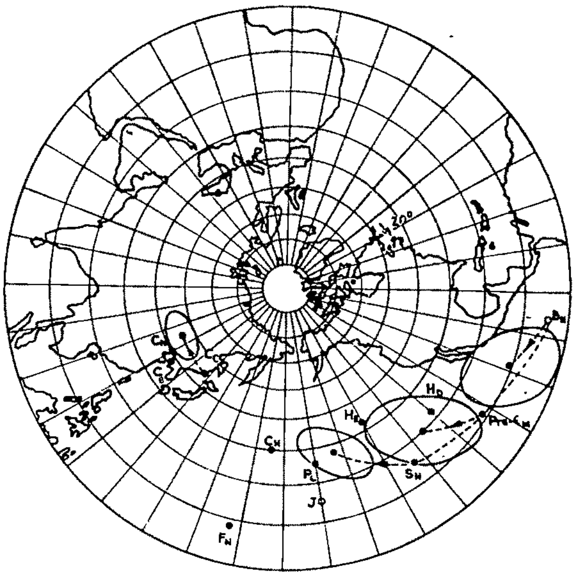
The rocks were cut and measured under an astatic magnetometer in the manner described by Collinson *et al.*[1]. The calculation of the relevant mean directions, pole positions and statistics, following the methods of Creer *et al.*[2] and Fisher[3], are given in Fig. 1*A* and in Tables 1 and 2. In these calculations the means of four measurements per sample are used and not individual measurements.

The difference between the mean directions of the two Pre-Cambrian collections is quite marked, and consequently all relevant calculations have been made for each set as well as the means for the whole group. In view of the size of sample and the uncertainty of the stratigraphic relationship of the two areas it would seem unwise to attribute much significance to this result. It is of interest, however, that this group mean pole position is fairly close to one of the Hakatai Shale results quoted by Creer *et al.*[2], and quite different from the Keweenawan of Du Bois[4].

The pole position obtained from the lower Carboniferous rocks lies considerably to the east of those quoted by Creer *et al.*[2] and Martinez and Howell[5]. This difference disappears if it could be assumed that in post-Carboniferous times there had been a relative anticlockwise rotation of Newfoundland with respect to the rest of North America. This is illustrated in Fig. 1*B*, where a rotation of 20° has been assumed.



A



B

Fig. 1*A*. Stereographic plot of the directions of magnetization of Pre-Cambrian and Carboniferous (Mississippian) samples from Newfoundland. (Signal Hill and Blackhead samples separately linked.) All north-seeking poles point down. * represents the mean direction enclosed within the circle of confidence

Fig. 1*B*. Plot of pole positions of American Pre-Cambrian and Carboniferous rocks, illustrating the effect of a 20° rotation on the Newfoundland samples. Ellipses of confidence are drawn around the Newfoundland pole positions.
Pre-ε_M mean of all Newfoundland Pre-Cambrian (S_H, Signal Hill; B_H, Blackhead collections). H_{D_1} and H_R pole positions of Hakatai Shale samples according to Doell and Creer *et al.* P_L, C_H, FN, J, Portage Lake, Copper Harbour, Freda and Nonesuch, and Jacobsville divisions of the Middle and Upper Keweenawan. (Jacobsville and Blackhead poles are south of the equator.) C_C pole position of Codroy samples; C_N and C_B pole positions of Naco Sandstone and Barnet Shale samples

The effect of such a rotation upon the Pre-Cambrian pole positions is to improve greatly the agreement with the rest of North America. The group mean position approaches those obtained by Runcorn and Doell for the Hakatai Shales, while the new pole position of the Signal Hill samples even suggests possible correlation with the Portage Lake horizon of the Keweenawan[4]. This is clearly seen in Fig. 1*B*, where the re-oriented pole positions are enclosed within their ellipses of confidence.

This suggested rotation is based entirely on palæomagnetic considerations; whether or not it is entirely fortuitous depends upon geological considerations, and it appears (Westoll, T. S., personal communication) that such a movement has been suggested by some geologists.

The assistance of Prof. T. S. Westoll, Drs. D. M. Baird, N. D. Opdyke and members of the Durham University Exploration Society is gratefully acknowledged. Thanks are also due to A. Major and W. Rutherford for their help in the preparation and measurement of the rocks.

A. E. M. Nairn

Department of Physics,

D. V. Frost
B. G. Light

Department of Geology,
King's College,
Newcastle upon Tyne, 1. Jan. 8.

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PHYSICAL SCIENCES

Anomalous Night-Time Reception of a Major Solar Radio Burst

During the early morning hours of March 8, 1958, the planet Jupiter was under observation by a total of five different receiving arrays at the University of Florida Radio Observatory. Two of these arrays operated at a frequency of 18 Mc./s., two at 22·2 Mc./s., and one at 27·6 Mc./s. Both pen recording and aural monitoring of the signals by an observer were employed. At 0235 U.T. an unusual event began simultaneously on all five channels, consisting of a single very intense burst of noise which slowly rose to a maximum, and even more slowly declined over a total period of about 2 min. During this interval the observer was able to obtain an excellent record of the polarization of the disturbance with the 22·2 Mc./s. polarimeter, which was kept in stand-by condition during all periods of observation.

The outburst differed from typical Jupiter noise in a number of respects: (1) the relatively smooth rise and fall of the signal was slower by at least an order of magnitude than any previously observed single Jupiter pulse[1]; (2) no Jupiter pulse had been observed at this Laboratory simultaneously on all three frequencies; (3) analysis of the polarimeter record showed the burst to be polarized in the left-hand elliptical sense, whereas all the Jupiter noise analysed here had shown right-hand circular or elliptical polarization. Although the event had occurred more than four hours prior to sunrise, it was inescapable that it displayed many of the characteristics of a solar burst, rather than a Jupiter pulse.

Subsequent correspondence with C. A. Shain in Australia disclosed that a major solar burst had indeed been observed at stations in Potsdam, Uccle, Nogaya, Tokyo and Sydney, on the sunlit hemisphere of the Earth, at the same instant as the event described above. Unfortunately, all the available observations were at frequencies much higher than those of the Florida station; but the observations made at Sydney at 108 Mc./s. were off-scale and were described as possibly "one of the largest bursts ever observed near this frequency". It seems clear, then, that the event observed in Florida was this major solar burst, propagated by some means far into the dark hemisphere of the Earth.

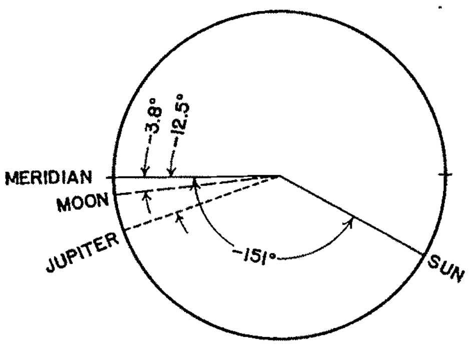

Fig. 1. Polar diagram showing the relationships between the bodies of interest

The relevant relationships are shown in Fig. 1, which is a polar diagram of the Earth, with the directions of the bodies concerned shown in terms of hour angle. It should be remarked in connexion with this diagram that the antenna patterns are centred on the meridian and are approximately 30° wide in the east–west direction. Of interest is the fact that the Moon was actually closer to the centres of the antenna beams than was Jupiter at 0235 hr. U.T., so that a lunar reflexion of the burst immediately suggests itself. If one assumes a lunar reflexion coefficient of 0·15 and a directivity factor of 4 due to scattering[2], the attenuation factor for a lunar echo would be about 10^{-5}. The peak flux recorded at Florida at 18 Mc./s. was off-scale at approximately 6×10^{-20} watt m.$^{-2}$ (c./s.)$^{-1}$, suggesting that at this frequency the directly received burst would have had an intensity of about 6×10^{-15} watt m.$^{-2}$ (c./s.)$^{-1}$ at 18 Mc./s. The Australian observers estimated the intensity as being of the order of 10^{-17} watt m.$^{-2}$ (c./s.)$^{-1}$ at 108 Mc./s. Although no direct comparison can be made because of this large difference in frequency, the orders of magnitude do not seem entirely to exclude the possibility of a lunar reflexion. (We would welcome intensity data from this event from any station which happened to record it at a frequency nearer 18 Mc./s.).

The other possibility is, of course, that the radiation penetrated the ionosphere through an anomalous 'thin' spot in the daylight hemisphere, and was then propagated around the Earth by the usual modes of transmission. In this connexion, Shain was kind enough to point out to us the curious focusing at the antipodal point of the 40-Mc./s. signal from *Sputnik I*, which was reported by Wells[3].

Operation of the Florida Radio Observatory is assisted by funds from the National Science Foundation, the U.S. Army Office of Ordnance Research and the Office of Naval Research.

ALEX. G. SMITH
T. D. CARR
W. H. PERKINS

Department of Physics,
University of Florida,
Gainesville. Jan. 23.

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Polynomial Representation of Steam Tables

THE mechanization of computation concerning steam plant design has been greatly frustrated by the difficulty of having to use steam tables. An experiment carried out using the University of Manchester Mark I digital computer a year ago showed that while it was quite possible to have the whole contents of the Keenan and Keyes table[1] stored within the machine, calculations of turbine condition lines and cycle efficiencies were slowed down considerably by the business of searching through the table for particular entries. A major advance in the mechanization of steam-cycle calculations has now been accomplished by the derivation at Risley of sets of polynomials which accurately represent the thermodynamic properties of steam.

The steam tables tabulate enthalpy, entropy and specific volume of dry steam as functions of pressure and temperature. It has been found possible to fit each of these thermodynamic functions by a single polynomial in $U = \log p$ and:

$$V = \frac{B\{(t + A)^{-1} - C\}}{B - \log p} \qquad (1)$$

where t is temperature in degrees F., and p is pressure in lb./sq. in. and A, B, and C are constants.

The temperature-range covered by these approximations is from saturation to 1,600° F. The pressure-range is from 1 lb./sq. in. in the case of enthalpy and specific volume and from less than 5 lb./sq. in. in the case of entropy up to the critical pressure.

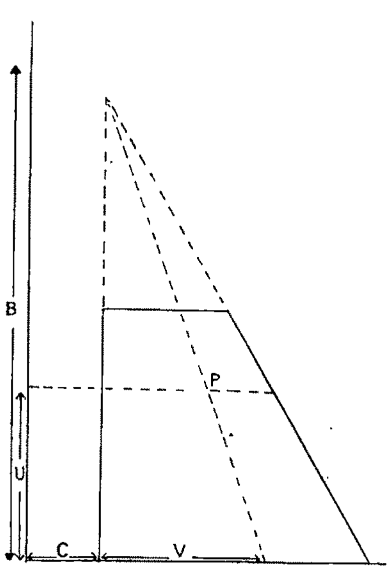

Fig. 1

It is essential to choose the arguments, U and V, of the polynomial so that points outside the saturation line are not included in the rectangle defined by the ranges of U and V. It was found that, with a suitable choice of A, a plot of $\log p$ against $1/(A + t)$ at saturation gives an excellent straight line over the whole pressure-range. Thus for variables $\xi = \log p$, $\zeta = 1/(A + t)$ the steam functions are defined over a trapezium (Fig. 1).

A second transformation, $U = \xi$, $V = \dfrac{\zeta - C}{B - \xi}$ transforms the trapezium into a rectangle, which does not contain points from outside the tables. The polynomials were then obtained by a two-dimensional modification of the method described by Lanczos[2]. The functions were fitted by:

$$F(x,y) = \sum_{k=0}^{9} \sum_{l=0}^{9} C_{kl}\, T_k(x)\, T_l(y) \qquad (2)$$

$$\text{where } x = a_1 U + b_1, \quad -1 \leqslant x \leqslant 1$$
$$y = a_2 V + b_2, \quad -1 \leqslant y \leqslant 1$$

and T_n is the Chebyshev polynomial of order n.

$$C_{kl} = A_{kl} \sum_{\alpha=0}^{9} \sum_{\beta=0}^{9} f(x_\alpha, y_\beta) \cos\frac{k\pi}{20}(2\alpha + 1) \cos\frac{l\pi}{20}(2\beta + 1) \qquad (3)$$

where, for $i \neq 0$, $j \neq 0$,

$$A_{00} = \frac{1}{100},\ A_{i0} = A_{0j} = \frac{1}{50} \text{ and } A_{ij} = \frac{1}{25} \qquad (4)$$

$$\text{Also} \quad \left.\begin{aligned} x_\alpha &= \cos\frac{\pi}{20}(2\alpha + 1) \\ y_\beta &= \cos\frac{\pi}{20}(2\beta + 1) \end{aligned}\right\} \qquad (5)$$

The values of the function at (x_α, y_β) were obtained by two-dimensional interpolation in the steam tables. To facilitate this, the variables were slightly modified so that the points required near the saturation boundary were not at the very edge of the tabulated values. The entropy function begins to change rapidly with p at pressure less than 4 lb./sq. in., and if the tables are fitted from 1 lb./sq. in. upwards, the high-order coefficients in (2) do not become negligible. However, by excluding pressures less than 5 lb./sq. in. from the region fitted, this difficulty was overcome. Finally (2) was transformed to give a simple polynomial in U and V.

For use in a digital computer all that need be stored are the coefficients of the polynomials, which occupy a space less than 1½ per cent of that required by the full steam table, and 'table look-up' is completely eliminated. The necessary routines have been prepared for the Risley *Mercury* computer and the values of the coefficients of the polynomials will appear elsewhere.

This communication is published by permission of Dr. H. Kronberger, director of Research and Development, United Kingdom Atomic Energy Authority.

W. G. Berry
G. Black
J. A. Enderby

Research and Development Branch,
Computer Group,
U.K. Atomic Energy Authority,
Risley.

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Ductility of Rhodium

Although rhodium is a face-centred cubic metal which should possess numerous planes and directions of slip it is, at room temperature, an extremely difficult metal to form into strip and wire. Usually rhodium is hot-worked, the working temperature being gradually reduced during successive stages until the metal develops a fibrous structure, when at thin gauges it can be subjected to moderate cold-working operations.

The reason for the poor room-temperature ductility of rhodium is not known, but has been ascribed to impurities, although, from experiments using high-purity rhodium, Bale[1] concludes that it is more probable that rhodium is subject to deformation mechanisms different from those for other face-centred cubic metals.

It appears unlikely that in a face-centred cubic metal slip will occur preferentially on planes other than (111), since this would involve a non-statistical distribution of dislocations with Burgers vectors having only very small components in this plane. However, segregation of impurity atoms around dislocations might produce an atmosphere effect greatly increasing the resolved shear stress for glide; this would be reduced at high temperatures, when diffusion would enable the atmosphere to move with the dislocation and such a process would presumably result in a yield-point being observed. Another possibility is that slip is finer in rhodium and that hardening is accentuated by intersections, impurities and point defects.

If any one of these hypotheses is correct, it might be expected that a single crystal of rhodium would be of similar low ductility to the polycrystalline material. If, however, lack of ductility is due to grain-boundary weakness or to the locking of dislocations at crystal boundaries, because of impurities or for other reasons, such a single crystal might be expected to exhibit a greater degree of ductility and a lower rate of strain-hardening than when in polycrystalline form.

Consequently, as a preliminary to a more comprehensive investigation on the deformation of rhodium, a single-crystal bar of the metal was prepared by the electron-bombardment floating-zone melting technique[2,3].

The bar was made from rhodium of normal commercial purity (Table 1), the starting material being an annealed hot-swaged bar, 0·165 in. diameter and hardness 180 diamond pyramid number, prepared from a compact sintered *in vacuo* and heated during swaging in an atmosphere of hydrogen. During zone melting, a considerable amount of evolution of gas occurred and seventeen passes of increasing bombarding power were necessary before the bar could be

Table 1. SPECTROGRAPHIC ANALYSIS OF RHODIUM

	Original bar (per cent)	Zone-melted bar (per cent)
Platinum	< 0·01	< 0·01
Palladium	0·01	0·0001
Ruthenium	0·026	0·026
Iridium	0·08	0·08
Iron	0·016	0·006
Lead	< 0·0001	< 0·0001
Silicon	Trace	Minute trace

Traces: gold, silver, aluminium, calcium, chromium, copper, magnesium, manganese, molybdenum, nickel, titanium, vanadium, tungsten.

Not detected: osmium, arsenic, bismuth, cadmium, cobalt, gallium, germanium, indium, rhenium, antimony, tin, tantalum, thallium.

zoned without further gas evolution. At this stage the zoned region was single crystal, having grown within a few degrees of the [110] direction, and no further zone refining was carried out. The speed of zoning was 0·5 in./min., the final bombarding current and voltage were 100 m.amp. and 0·7 kV., and the operating vacuum approximately 10^{-4} mb. The hardness of the zoned bar was 190 diamond pyramid number and its spectrographic analysis is given in Table 1.

The diameter of the single-crystal bar varied between 0·150 in. and 0·170 in., and it was found that it could be cold swaged without intermediate anneal to wire 0·050 in. diameter, a reduction of approximately 90 per cent in area. Cold reduction of similar bars of this material in the polycrystalline state was possible only to a very limited extent before intercrystalline fracture occurred.

The wire produced from the single-crystal bar, when annealed *in vacuo*, became polycrystalline and could not be subjected to further cold work without intercrystalline fracture. It can therefore be concluded that crystal boundaries do play an important part in the cold-deformation of rhodium, and that the presence of grain-boundary impurities may have a role in this process.

The fact that the analyses of Table 1 may suggest that the concentration of impurities is much lower than is normal to produce grain-boundary embrittlement in face-centred cubic metals is not necessarily evidence that the modes of deformation of rhodium differ essentially from those of other face-centred cubic metals, as the significant impurities may be non-metallic or otherwise not readily determined by the normal methods of analysis. This is an aspect which requires further investigation.

Permission from the Admiralty and the Mond Nickel Co., Ltd., to publish this communication is gratefully acknowledged.

A. CALVERLEY

Services Electronics
Research Laboratory,
Baldock, Herts.

D. W. RHYS

Mond Nickel Co., Ltd.,
Bashley Road,
London, N.W.10.
Jan. 20.

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Adsorption and Desorption of Moisture in Fired Ceramic Materials

RECENT communications[1,2] on moisture expansion in fired ceramic materials raise a number of points on which we would like to comment. This phenomenon has been studied in these laboratories for many years, and we summarize below some of the conclusions to which our experimental data have led us.

We do not think moisture expansion can properly be referred to as 'permanent', since under suitable conditions of temperature and pressure it can be reversed. Water can be removed from a steam-expanded material by heating to 110° C., and this desorption is accompanied by a contraction. Heating for a long time at 300° C. usually removes more water, up to about 90 per cent of that adsorbed. Heating at still higher temperatures is accompanied by further gradual loss of water and contraction, and for complete desorption it is necessary to heat to at least 1,000° C. Weight measurements also show that all the water adsorbed during steam-treatment for, say, 20 hr. at 50 lb./sq. in., can be removed by heating to 300° C., and this desorption is accompanied by a complete reversal of the change in size. This suggests that short-term expansion in steam is mainly due to physical adsorption.

Materials desorbed at 1,000° C. adsorb moisture and expand immediately on cooling from this temperature, and continue to do so down to room temperature. This high-temperature adsorption and desorption involve some mechanism other than physical adsorption, and we believe that in addition to the surface activity there is also a penetration process. The practical consequences of these observations are that, unless a standard zero is established, moisture – expansion measurements on treated materials may include an expansion of unknown extent that has occurred during cooling in the kiln. In order, therefore, to obtain strictly comparable values for moisture expansion after leaving the kiln, all pieces should be subject to a preliminary desorption procedure.

In our experience, involving measurements made on some samples for as long as 1,000 hr. in steam at 50 lb./sq. in., and for 3 years at room temperature and atmospheric pressure, we have never found an equilibrium or maximum size to be attained, although the rate of expansion falls off with time. There is evidence that in some cases there is a progressive increase in internal surface area with steam treatment. We believe that a continuous penetration of water into the glassy phase can go on for very long periods of time. It may be, of course, that different considerations apply when steam at higher pressure is used.

In this connexion, we have found that a given weight of water adsorbed at room temperature produces a change in size different from that produced by adsorption of the same weight of water in steam treatment. Moisture expansion results obtained by steam treatment have been shown to be misleading as a guide to moisture expansion at room temperature.

The effect of firing appears to be two-fold. Vitrification produces changes in internal surface area, and over small ranges moisture expansion can be fairly accurately related to surface area. Over wider ranges, changes in the mineralogical composition of the fired material play a dominant part. We have shown that the main crystalline phases in fired ceramic materials have a negligible moisture expansion, and that glassy phases have a high expansion.

Penetration of open glassy structures by water would explain the continuation of moisture expansion over long periods of time, which cannot be explained in terms of surface activity alone. Moulson and Roberts[3] have recently shown experimentally that penetration of water into silica glass does in fact occur in relatively short periods of time within the temperature-range 600–1,200° C. Studies of adsorption of water vapour on silica glass at room temperature by Barrett, Birnie and Cohen[4], show long-term continuous uptake of water, suggesting a kind of diffusion process.

In view of these findings, we do not think that 'rehydration' is a suitable term to apply to the phenomenon of moisture expansion in fired ceramic materials.

A more detailed account of some of this work was presented by A. W. Norris to the Sixth International Ceramic Congress, and will be published in due course[5]. We are indebted to Dr. A. T. Green, director of research, for permission to publish this communication.

F. VAUGHAN
A. DINSDALE

British Ceramic Research Association,
Stoke-on-Trent.
Jan. 23.

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CHEMISTRY

Structural Chemistry of Promethium

THE physico-chemical properties of promethium and its compounds are generally predicted from knowledge of the properties of other lanthanides. However, since promethium lies between neodymium and samarium—two elements which show sensible differences in structural behaviour in some of their compounds—an experimental examination of promethium compounds is indicated. This will also throw light on general lanthanide chemistry.

Lanthanide sesquioxides exist in three crystal structures: hexagonal *A*; an ill-defined *B*; and cubic, nearly fluoritic, *C*, the crystal habit depending on the temperature and the atomic number of the lanthanide[1].

Normally, sesquioxides up to and including neodymium exist in form *A*, and those from samarium onwards in form *C*. This behaviour is also reflected in the different capacity of sesquioxides for dissolving, in the solid state, in the fluorite lattice of some dioxides (of cerium, praseodymium, thorium) to give anomalous mixed crystals: sesquioxides up to and including those of neodymium dissolve partially in the fluorite lattice, while those of samarium onwards dissolve in all compositions[2]. Nothing is known regarding the sesquioxide of promethium.

Direct investigations on promethium sesquioxide are not practicable because of the difficulties in obtaining sufficient quantities of the compound. We therefore employed a method using the radioisotope promethium-147, carrier-free.

Measurements of radioactivity were carried out systematically over a large range of temperatures to determine the distribution of promethium sesquioxide between two non-soluble solid phases: one with a fluorite lattice and the other with an *A* structure. These were solid solutions of cerium, praseodymium and thorium dioxides saturated with sesquioxides, and sesquioxides in the *A*-form saturated with dioxides respectively. The two solid phases were separated by dissolving the *A* phase only with suitable solvents.

In all the experiments the promethium sesquioxide accumulated in the cubic phase (*C* form); reversal seemed to occur only at very high temperatures. We therefore infer that over a large range of temperatures promethium sesquioxide has a nearly fluoritic structure.

This type of investigation could also be used to study the changes of structure with temperature in the solid state of dioxides with fluorite-type structures. Details of this work will be published elsewhere.

M. BRUNO
U. CROATTO

Nuclear Chemistry Centre of the
National Research Council,
Padua. Dec. 1.

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Tetra-co-ordination of Nickel(II)—Some Complexes with *Cyclo*hexylphosphine

THE problem of the tetra-co-ordination of nickel(II) has recently been the object of much interest[1–3] owing to the peculiar situation of this ion in the field of co-ordination chemistry, and because of the many opportunities for testing theoretical predictions on the structural, magnetic and optical properties of transition metal complexes. Of particular interest are the complexes of the type NiX_22PR_3. These seem to be clear examples of pure tetra-co-ordination around nickel(II). We had previously examined by X-rays the crystal structure of the red diamagnetic compound[4] $NiBr_22PEt_3$, and found it to be trans-planar as expected. We did not detect any co-ordination along the other axis (unpublished work), as occurs in other cases, for example, in nickel *bis*dimethylglyoxime[5].

Issleib *et al.*[6], examining the co-ordinating power of tri*cyclo*hexylphosphine (PCy_3; Cy = *cyclo*hexyl), mentioned the compound $NiBr_22PCy_3$ and described it as an olive-green substance. Since the ligand field around the nickel ion should not be greatly different from that in the analogous complexes containing aliphatic phosphine, this compound was obviously of interest. The green or blue colour has, in fact, been found only among the paramagnetic forms of the nickel–phosphine series[1,7]. Although ligand field theory does not justify any simple relationship between colour and magnetic properties, or structure, many regularities have been observed at one time or another and the relationship is often mentioned as an empirical rule.

It seemed of interest to investigate this class of compounds also, with the aim of collecting more experimental data in order to throw further light on the general problem.

We prepared the following compounds: $NiBr_22PCy_3$, $NiCl_22PCy_3$, $Ni(SCN)_22PCy_3$. Attempts to prepare the nitrate and the perchlorate did not give samples of sufficient purity, although green precipitates, consisting mainly of the phosphine complexes, were obtained. Analyses and characteristics of the compounds are shown in Table 1.

Single crystals of bromide and thiocyanate have been examined by X-rays with the following results: $NiBr_22PCy_3$: triclinic; a, $9{\cdot}98_2$; b, $10{\cdot}2_8$; c, $10{\cdot}7_4$; α, 112° 44′; β, 109° 41′; γ, 90° 41′; z, 1; space group $P\bar{1}$; observed density, 1·34; calculated, 1·37. $Ni(SCN)_2PCy_3$: monoclinic; a, $9{\cdot}63_7$; b, $13{\cdot}3_8$; c, $17{\cdot}8_3$; β, 117° 52′; z, 2; space group, $P2_1/c$; observed density, $1{\cdot}19_7$; calculated, 1·208.

In both cases the nickel atoms lie at centres of symmetry of the crystal, thus showing a trans-planar arrangement of the four ligands.

Table 1. PROPERTIES AND CHARACTERISTICS OF $NiX_2 2PCy_3$ COMPOUNDS

Compound	$Ni(SCN)_2 2PCy_3$	$NiCl_2 2PCy_3$	$NiBr_2 2PCy_3$
Colour	Orange-yellow	Red	Olive-green
Melting point (deg. C.)	230	227	204
Analysis (per cent, calculated values in brackets) C	61·6 (62·0)	62·6 (62·5)	55·1 (55·5)
H	8·8 (9·0)	9·3 (9·6)	8·6 (8·5)
Ni	7·9 (8·0)	—	7·4 (7·5)
Magnetic moment*	Diamagnetic	Diamagnetic	Diamagnetic
Dipole moment* (in benzene)	~0	~0	1·9

* Magnetic moments were measured on the powdered solids by means of a Sucksmith balance. Dipole moments were measured in benzene solution. The compounds are all monomeric in freezing benzene.

Table 2. FREQUENCIES AND MOLAR EXTINCTION COEFFICIENTS OF THE ABSORPTION MAXIMA OF COMPOUNDS $NiX_2 2PCy_3$

Band		X = SCN	X = Cl	X = Br
I	ν(cm.$^{-1}$)	33,500	36,000	35,700
	ε	15,000	4,000	9,000
II	ν(cm.$^{-1}$)			27,000
	ε	—	—	(< 1,000)
III	ν(cm.$^{-1}$)	26,300	25,600	23,300
	ε	12,500	10,000	6,000
IV	ν(cm.$^{-1}$)	(22,000)	20,000–19,000–18,000	18,000–17,000–16,500
	ε	(~500)	~500	~500
V	ν(cm.$^{-1}$)	11,500	11,700	11,500
	ε	1,500	200	1,500

Absorption spectra in benzene were taken between 40,000 and 10,000 cm.$^{-1}$. In Table 2 frequencies and molar extinction coefficients of the absorption maxima are summarized.

The diamagnetism of the three compounds rules out any simple relationship between magnetic properties and colour in this series. A comparison with the series containing phenylphosphine[1] is of interest. In this series, there is a transition from blue-green paramagnetic forms (X = Br, Cl) to a red diamagnetic one (X = SCN); in the former series diamagnetism is already attained with the bromide. This behaviour can be interpreted, from the point of view of ligand field theory, as an enhancement of the field along the P—P axis in going from the aromatic to the saturated phosphines. When the field along the P—P axis is weak it is necessary to reach a stronger field along the X—X axis (X = SCN) in order to stabilize the singlet in its ground-state. There seems to be some sort of additive effect for the fields along the two symmetry axes. It may well be that for weak fields the steric arrangement of the ligands becomes a distorted tetrahedron (as Venanzi[1] seems to find in the case of the aromatic phosphines).

The X-ray results found for $NiBr_2 2PCy_3$ do not agree with the dipole moment of 1·9 Debyes. It is true that this value (obtained making an allowance of 25 per cent P_E for the atomic polarization) refers to steric arrangement of the molecule in solution, where the situation may be different[2,8] from the solid state; nevertheless, the problem of the dipole moment of this compound requires further investigation.

Our X-ray determinations do not exclude as yet the possibility of a co-ordination along the z-axis as well, but analogy with the ethyl phosphine case seems to rule out such a possibility except perhaps for the SCN^- compound, where the nitrogen atom also has co-ordinating power.

The main features of the absorption spectra have been tentatively interpreted as follows. The band around 35,000 cm.$^{-1}$ is attributed to a charge transfer process involving the P—Ni bond electrons. The bands between 23,000 and 26,000 cm.$^{-1}$ are the same type of charge transfer bands for the Ni—X bonds. The weaker bands in the visible region are the well recognized g—g forbidden transitions between d-levels of the central ion. These bands show evidence of structure (see values for band IV in Table 2) which could arise from the overlapping of different electronic transitions in this region. The bromide band at 27,000 cm.$^{-1}$ is probably also of this type. It is interesting to note that the extinction coefficient of these bands is much higher than is usually found in cases of higher symmetry[9]. We are investigating the details of these spectra from the point of view of ligand field theory.

A full account of this study will be published elsewhere.

Thanks are due to Dr. S. T. Hedgcock and Mr. R. O. Kornelsen of the Physics Department of the University of Ottawa (Ontario) for the magnetism measurements.

ALDO TURCO
Istituto Chimica Generale,
Università di Padova.

VLADIMIRO SCATTURIN
Centro Strutturistica Chimica C.N.R.,
Padova.

GIOVANNI GIACOMETTI
Istituto Chimica Fisica,
Università di Padova.

Dec. 2.

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Gas Phase Oxidation of Hydrocarbons : Endothermic Nature of the Initial Stage of Reaction

IT is generally agreed that the oxidation of hydrocarbons occurs by steps such as :

$$RH + O_2 \longrightarrow R\cdot + HO_2\cdot + Q' \qquad (1)$$

$$R\cdot + O_2 \begin{cases} \xrightarrow{+M} RO_2\cdot - Q'' & (2) \\[2ex] \longrightarrow R' + HO_2\cdot - Q''' & (3) \end{cases}$$

$$R\cdot,\ RO_2\cdot,\ R' \longrightarrow \text{further reactions finally leading to oxides of carbon and water}$$

The initial stage of oxidation as depicted by (1) is endothermic, while (2) and (3), and also many subsequent reactions, are exothermic. Experimentally, however, no evidence seems to have been furnished which would demonstrate the endothermic nature of the initial stage of hydrocarbon oxidation. What is well known is that the reactions are exothermic : cool flames readily appear in the early stages of oxidation of numerous hydrocarbons, particularly n-alkanes (excepting methane and ethane), and cause a considerable rise in the temperature of the reacting gases.

We have recently studied the pre-flame reactions of a wide variety of hydrocarbons in a flow system in silica reaction chambers of different shapes and sizes. A number of thermocouples measured the temperature of the various parts of the system. Those inside the chamber were prevented from exerting any catalytic effects on the reaction mixture by enclosing them in thin-walled silica sheaths, while others were attached to the outside surface of the chamber and the connecting parts. The onset of the oxidation reactions and their progress were followed by measuring the consumption of oxygen as well as by the appearance of oxides of carbon in the gases leaving the reaction chamber. Oxygen was measured by means of a paramagnetic analyser while the oxides of carbon were measured by means of infra-red instruments.

The fuel and air were allowed to flow, at desired rates, into a pre-mixing section maintained at a temperature a few degrees above the boiling point of the hydrocarbon. The mixture was heated on its way to the reaction chamber held at a uniform temperature inside a furnace. The temperature of the furnace was gradually raised so that the oxidation reactions could be studied from the temperature at which they become detectable to the point at which ignition occurs. Until the instant of commencement of any trace of reaction, the temperature of the fuel/air mixture inside the chamber was the same as that of the surface of the chamber. However, as soon as there was the first sign of consumption of oxygen, the temperature of the reacting mixture began to drop below the temperature of the chamber surface. In the case of a stoichiometric *n*-heptane/air mixture with a residence time of 0·9 sec. in a reaction chamber with surface to volume ratio of about 3·3 cm.$^{-1}$, a drop in temperature of 4–5 deg. C. was observed. The drop at the commencement of the reaction increased when concentration of fuel was increased. At a few degrees higher reaction-chamber temperature, when the oxides of carbon began to be formed in appreciable amounts, the temperature of the reacting gases rose above the chamber surface temperature. It increased most markedly with the appearance of cool flames. At temperatures above the cool flame region, in the zone of negative temperature coefficient, the temperature of the reacting gases gradually fell to the level of the temperature of the chamber surface. Thereafter the temperature of the reacting gases and the reaction-chamber surface stayed close to each other until very near the temperature at which normal ignition occurred.

Similar behaviour with regard to the temperature difference in the reaction mixture and that of the chamber surface has been observed in the case of a number of hydrocarbons and related substances. Detailed results on these will be presented elsewhere.

An interesting point regarding the present observations on the drop in temperature of a reacting fuel/air mixture in the initial stages of reaction is its possible relationship to the drop in pressure observed during the induction period of oxidation in closed chambers. Such an observation was first made in the oxidation of methane by Minkoff and Salooja[1]. It was then thought that the drop in pressure might have been due to the formation of methyl peroxide which would involve an overall diminution in the number of molecules. However, no methyl peroxide was detected in the products of reaction during the induction period. It seems possible that the observed drop in pressure of the reaction mixture might have been caused by the endothermic initial stage of reaction.

I wish to thank the Directors of "Shell" Research, Ltd., for permission to publish this work.

K. C. Salooja

Thornton Research Centre,
"Shell" Research, Ltd.,
P.O. Box 1,
Chester.
Jan. 16.

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A Rapid Method for determining the Concentration of Ammonium Sulphate Solutions

The separation of proteins and enzymes by the ammonium sulphate gradient elution technique has been reported by a number of workers[1–4]. Dixon[5] and Kunitz[6] have published a useful nomogram and equation, respectively, for use in the preparation of ammonium sulphate solutions. While the concentration of ammonium sulphate in a solution can be determined by the usual methods (that is, by distillation and titration, by specific-gravity determinations, nesslerization, or by gravimetric methods) they are all time-consuming, often involve large dilutions of the sample and, in general, are not useful for the routine analysis of a large number of samples. The use of refractometry has been investigated in the search for a more rapid method of measuring the concentration of ammonium sulphate in the fractions collected by the gradient elution technique as well as in the classical precipitation method.

Table 1. Refractive Index of Ammonium Sulphate Solutions

Molarity	Temperature				
	30·60°	24·90°	20·50°	13·25°	0·10°
Water	1·3316	1·3321	1·3327	1·3332	1·3338
0·4138	1·3401	1·3410	1·3414	1·3420	1·3430
0·9658	1·3508	1·3514	1·3518	1·3526	1·3539
1·5118	1·3602	1·3610	1·3617	1·3625	1·3640
2·0837	1·3698	1·3703	1·3708	1·3715	1·3730
2·5900	1·3774	1·3781	1·3784	1·3791	1·3808
2·9152	1·3821	1·3830	1·3834	1·3839	1·3855
3·6265	1·3919	1·3922	1·3924	1·3932	1·3949
4·0645	1·3970	1·3975	1·3979 saturated	saturated	saturated

The results of this investigation are shown in Table 1. Ammonium sulphate, when added to water, was found to produce a large increase in the refractive index. However, the increase in the refractive index is not directly proportional to the concentration of ammonium sulphate but, as one might expect, is dependent upon the density of the solution also. This relationship can be adequately expressed by the following equation:

$$y = ad(RI_1 - RI_2) \text{ (temp. const.)} \qquad (1)$$

where y is the molarity of the ammonium sulphate solution, a is a constant, d is the density of the solution and RI_1 and RI_2 are the refractive indices of the solution and water respectively.

The concentration of the solution can also be calculated by the following equation:

$$y = 0{\cdot}0403 + 41{\cdot}1\,(RI_1 - RI_2) + 309\,(RI_1 - RI_2)^2 \qquad (2)$$

where y, RI_1 and RI_2 have the same meaning as in equation 1. Equation 2, calculated by the least-squares method from the data of Table 1, eliminates the need for knowing the density of the solution.

It is not necessary to control, or even to know, the temperature during the measurements as the change in refractive index per degree change in temperature is 0·0001 for both water and ammonium sulphate solutions. The only requirement is that the refractive index of the solution and of the water be measured at the same temperature. The presence of protein in the usual concentrations will not appreciably alter the results. For example, 1·0 per cent crystalline egg albumin was found to increase the refractive index of water by 0·0017. This is in agreement with the value of 0·0018 reported by Kirk[7].

The concentration of an unknown ammonium sulphate solution (0·50–4·06 *M*) can be rapidly determined by the above method with an overall accuracy of ± 1·0 per cent. (The accuracy is much better at the higher concentrations.) While the sensitivity of the method can be increased approximately ten-fold by the use of a dipping refractometer, the Abbe refractometer should prove adequate for determining the usual concentrations of ammonium sulphate employed in gradient elution and the precipitation of proteins.

It is to be emphasized that this method can, and often has, been applied to the determination of the amount of material in various kinds of solutions. Only the particular application of the method reported here is claimed to be original.

JOHN R. WHITAKER

Department of Food Technology,
University of California,
Davis, California.

ROBERT HUGHES

Department of Agricultural Chemistry,
Oregon State College,
Corvallis, Oregon.

Jan. 13.

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Adaptation of a Photometer for the Direct Recording of Column Chromatograms

THE direct recording of chromatograms presents several advantages: it saves time and labour and eliminates all errors inherent in a fraction collector. To actuate the recorder, a suitable method of detecting the eluting bands must be used. Out of several possibilities, absorption of light, especially ultra-violet light, seems the most generally useful, since many laboratories are equipped with a photometer. Although such devices are already mentioned in the literature[1,2], a detailed description seems to be lacking. The only drawback of such a method lies in the rather short expectancy of life of the hydrogen lamp used as source of ultra-violet light. This limits the application of the direct photometric recording method to chromatography of short duration (a few hours). Only the most difficult separations need, however, days or weeks, and most column elution methods can be speeded up by adequate pressure without excessive diminution in efficiency.

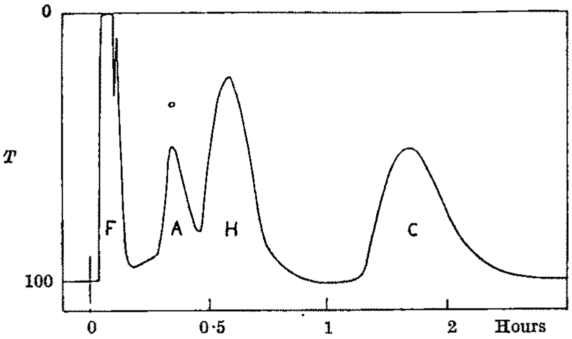

Fig. 1. Chromatography of 2 mgm. hop *a*-acid (California, 1958) (ref. 3). Bands in order of appearance: *F*, front; *A*, adhumulone; *H*, humulone; *C*, cohumulone. Column: 55 cm. × 0·9 cm. Stationary phase: silica gel (ref. 4), grain size 0·15–0·30, phosphate buffer *p*H 9·5 + 10 per cent methanol. Eluted with *iso*-octane which has been freed from oxygen by blowing through nitrogen. Pressure: 2·5 m. water. Flow-rate, 180 ml./hr. This speed can only be obtained when dust-free silica gel is used. Recorder speed, 2 in./hr. Wave-length, 276 mμ

Such a photometric direct recording device for column chromatograms was set up in our laboratory and Fig. 1 shows a typical result of a chromatography terminated in less than 2 hr., which would have taken much longer using the earlier methods (fraction collector—measuring each fraction—plotting the result and calculating).

The only difficulty lies in obtaining a straight and horizontal base-line, which is the same as saying that stability of the photometer in time is required. Providing a 'Beckman *DU*' spectrophotometer with a 5800 ERA energy-recording adapter and recording the energy output with a slow-speed recorder (we use a 'Varian *G*10' graphic recorder with chart roll speeds of 2 and 4 in. per hr.) a slanting base-line is obtained through voltage drop on the accumulator. Adding a Beckman battery power regulator No. 1900, a base-line slanting in the other direction is obtained, even with the lowest charge density. A straight base-line is then obtained by drawing off the battery a current of about 80 m.amp. The actual current intensity is regulated according to the base-line obtained on the recorder.

With a mains-fed Beckman power supply unit no difficulty was met in obtaining a stable and straight base-line, even for 12 hr. on end.

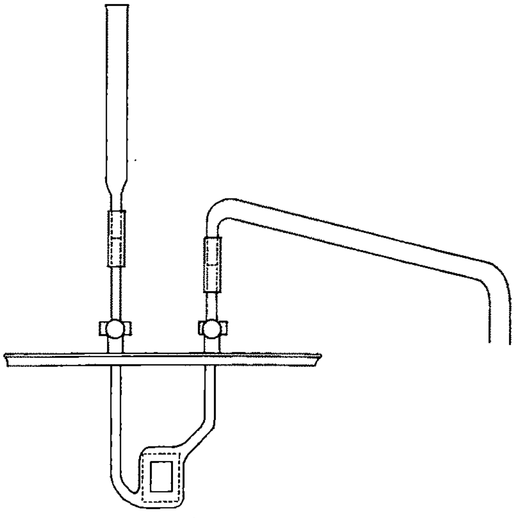

Fig. 2. Flow-cell

The column eluate flows through a special cell which must be as small as possible to prevent mixing. Out of several possible designs that shown in Fig. 2 is most satisfactory. It is made of ordinary glass; two openings are cut out and quartz windows are glued on. Such a flow-cell has a capacity of 2–3 ml. It is mounted in a specially made photobox-lid as shown. The joints are in plastic, although some of this material dissolves in organic solvents to give light absorption. The soluble components are soon all extracted, however, and no difficulties are noted afterwards. The chromatography of Fig. 1 was carried out on 2 mgm. of the mixture; but larger quantities can also be dealt with; it suffices to set the photometer at a wave-length where the specific extinction of the substances is lower. Since the recording is made with the co-ordinates time against transmission, quantitative results are difficult to obtain from it, and more so since the rate of flow of the columns can scarcely be expected to be rigorously constant. With the recording as a guide it is, however, easy to collect each substance separately and then to determine by some analytical method its amount.

To protect the photometer against accidents, the column is not mounted directly over the flow-cell, but about 30 cm. away from the photocell box. The eluate is then run in the flow cell through a small-bore connecting tube. Light penetrates normally in the photocell box through the glass arm of the flow-cell. This must be prevented with a piece of black cloth or paper.

M. Verzele

Laboratory for Organic Chemistry,
University of Ghent.

Jan. 18.

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BIOCHEMISTRY and PHYSIOLOGY

Electrophoretic Heterogeneity of Trypsin

The sedimentation behaviour of trypsin near *p*H 3 has been found to be characteristic of a monodisperse solute[1–3]. Bier and Nord[3] have also demonstrated that trypsin, between *p*H 4·0 and 5·0, behaves, in the absence of calcium ions, as an electrophoretically homogeneous protein. However, electrophoresis in the presence of a stabilizing concentration of calcium presents two clearly separated boundaries.

It is well known, however, that the instability of trypsin above *p*H 3 frequently complicates sedimentation and electrophoretic studies of this enzyme. As no study of the electrophoretic behaviour of trypsin near *p*H 2·3 (its point of maximum stability[4]) is available, such an investigation was carried out using paper electrophoresis and buffers of *p*H between 2·6 and 3. A subsequent paper will deal with the behaviour of trypsin at *p*H 2·5 in free boundary electrophoresis.

The electrophoreses were performed in a Durrum-type cell[5], using a potential of 2·5 V./cm., and the experiment was allowed to run for 20 hr. at room temperature (± 25° C.). The buffer used was a mixture of formic acid, pyridine and water in the following proportions: 4·5 : 1 : 94·5. The *p*H of this mixture is 2·6; the addition of 0·03 mole of calcium acetate raises this value to *p*H 2·8.

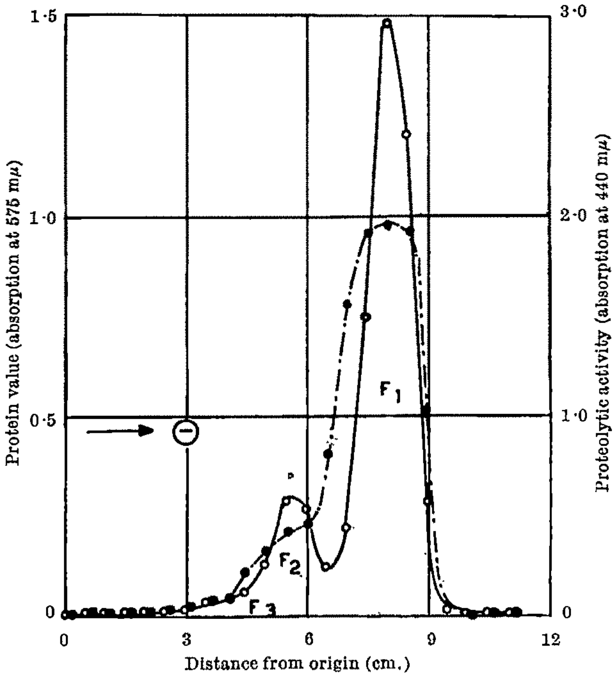

Fig. 1

The trypsin used was a sample of Worthington, twice crystallized, salt-free, batch *TR629SF*, which was found to be homogeneous by free boundary electrophoresis at *p*H 5 in the absence of calcium.

Samples of 0·08 ml. of 4 per cent trypsin dissolved in the same buffer were applied to a 8 cm. × 54 cm. strip of Whatmann No. 3 paper. Immediately after electrophoresis the strip was removed and while still wet, cut longitudinally in such a way to give three segments: two lateral ones, each 2·5 cm. wide, and a central one of 3 cm. width.

The central strip (3 cm. wide) was cut at 0·5-cm. intervals and each paper segment was transferred to a test-tube containing 3 ml. of azo-casein solution for the measurement of proteolytic activity by the method of Charney and Tomarelli[6].

Both lateral strips (2·5 cm. wide) were dried and the proteins dyed by Durrum's method[5]. Some strips were treated with a 0·2 per cent solution of ninhydrin in acetone, containing 5 per cent of pyridine.

The results of our experiments demonstrated that electrophoresis in the conditions used in this work shows the presence in crystallized trypsin of three different fractions, even in the absence of calcium (Fig. 1). When each of these fractions is extracted individually from the paper, lyophilized and again submitted to paper electrophoresis, no further heterogeneity was observed.

Of these three fractions the faster one (F_1) constitutes about 82 per cent of the total protein and accounts for 82 per cent of the proteolytic activity, as measured by the areas under the curves (protein curve and activity curve respectively). The two remaining fractions account for approximately 15 per cent (F_2) and 3 per cent (F_1) of the total proteins, the smaller fraction being also the slower one. The area under the activity curve of fractions F_2 and F_3, taken together, is about 18 per cent of the total. The proteolytic activity of the slower fraction, due to

Table 1

Ca^{2+} *M*	Protein (per cent)		
	F_1	F_2	F_3
0·0	82·7	14·7	2·6
0·025	82·5	14·8	2·7
0·030	83·1	14·2	2·6
0·050	82·5	15·2	2·3

Table 2

Ca^{2+} *M*	Percentage of total area under activity curve	
	F_1	$F_2 + F_3$
0·0	82·0	18·0
0·025	82·7	17·3
0·030	82·2	17·8

its low relative concentration, was not measured separately.

In our experiments, calcium ions up to 0·05 *M* had no influence on the quantitative distribution of the trypsin fractions (Table 1), or on the distribution of activity (Table 2). In both cases, that is, in the presence, as well as in the absence, of calcium, the only ninhydrin-reacting substances observed were the same three fractions mentioned before. The absence of trypsin-split products seems to indicate that no autolysis occurred during electrophoresis.

The identity of F_2 with the fraction which appears during free boundary electrophoresis at *p*H 5 in the presence of stabilizing concentrations of calcium ions is under investigation. A comparison of the proteolytic activity of F_1 with F_2 is also being made.

J. C. PERRONE*
L. V. DISITZER*
G. DOMONT

Instituto Nacional de Tecnologia,
Rio de Janeiro.
Nov. 25.

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* Fellows of the Conselho Nacional de Pesquisas.

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Albumin labelled with Iodine-131 in an Analbuminæmic Subject

THE behaviour of plasma proteins labelled with iodine-131 in the circulation of animals has been shown[1-3] to correspond with that of the same proteins biosynthetically labelled with carbon-14, supporting the view that the iodine label, if properly applied, may be a reliable indicator of the behaviour of unlabelled molecules.

A unique opportunity to test this directly was presented to us by the availability of a brother and sister with congenital absence of albumin in the plasma[4]. The sister was infused over 9 hr. with a mixture of 148 gm. re-crystallized human albumin (Behringwerke, Marburg) and 3·0 mgm. of the same albumin labelled with 0·80 atom iodine per mole according to procedures which have been described[5,6]. 10 min. after the end of the infusion the plasma of this subject contained 2·63 gm. albumin per 100 ml. and this value only declined to 1·10 gm./100 ml. at the end of 10 weeks, indicating a poor ability to catabolize albumin. During this period numerous measurements were made of plasma radioactivities and of absolute albumin concentrations by (*a*) paper electrophoresis and (*b*) precipitation of total plasma proteins with trichloracetic acid and extraction of albumins with ethyl alcohol[7].

The results (Fig. 1) indicate that specific radioactivities had not changed significantly after 7 weeks and therefore no discrimination had occurred between iodine-labelled and unlabelled albumin molecules.

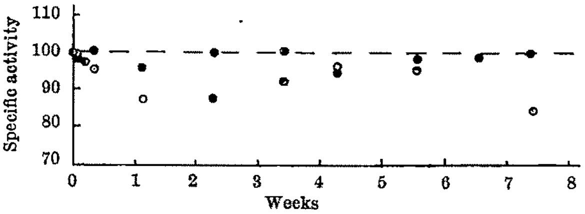

Fig. 1. Specific activities expressed as a percentage of that of the first sample: ⊙, based on electrophoretic estimation of albumin; ●, based on alcohol-trichloracetic acid albumin estimations

A full description is in preparation[8], including details of an earlier experiment on the same patient using a commercial albumin labelled with iodine-131. In this study the labelled albumin, which was injected 3 days before the infusion, was eliminated much faster than the unlabelled albumin.

T. FREEMAN
C. M. E. MATTHEWS
A. S. MCFARLANE

National Institute for Medical Research,
The Ridgeway,
Mill Hill,
London, N.W.7.

H. BENNHOLD
E. KALLEE

Medizinische Universitäts-Klinik und Poliklinik,
Tübingen.
Dec. 22.

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Effect of Clipping the Coat on the Thermoregulatory Reactions of Dairy Heifers

IT is well known that the coat has a marked insulative value, reducing the ability of the animal to dissipate heat to its environment. The reduction in the loss of heat occurs mainly in the conductive and convective components of loss[1]. The reduction in the potential loss of radiant heat may be of sizeable magnitude when the coat overlying the skin is thick and dense enough to prevent the skin from 'seeing' a cooler environment. There is the further possibility that the coat reduces the loss due to evaporation[2].

This reduction in the loss of heat may be critical in highly productive animals in a hot environment. It may be even more critical in such animals as dairy cattle, which are characterized by a relatively limited ability to dissipate heat by vaporization.

Table 1

	Rectal temperature (° F.)	Resp./min.	Surface temperature (° F.)	Total vaporization (gm./hr./cow)†	Ventilation-rate (l./min.)	Tidal air (l.)	Pulmonary vaporization (gm./hr./cow)	Feed consumed (lb./day)*	Water consumed (gal./day)*	Heat produced (cal./hr./m.²)
Before clipping	103·0	95·1	95·49	739·1	151·0	2·30	150·5	11·88	10·23	549
After clipping	102·9	91·1	95·95	732·3	146·0	2·34	142·2	13·64	10·35	623
Statistical significance of change	—	—	$P < 0 \cdot 01$	—	—	—	—	$P < 0 \cdot 05$	—	$P < 0 \cdot 05$

* Values for consumption of food and water from unpublished data of Ragsdale *et al.* (1958).

† Total values for vaporization from unpublished data of Yeck (1958).

An attempt has been made to evaluate the effect on some thermoregulative reactions by clipping the coat of dairy heifers. Four heifers (2 Brown Swiss and 2 Holstein), 20 months old, previously exposed for one month at high temperatures, were kept for two weeks in air at constant temperature and relative humidity in one of the climatic chambers at the University of Missouri Psychroenergetic Laboratory. The average of readings taken at 2-hr. intervals was 89·1 ± 1·39° F. for the air temperature and 69·0 ± 5·6 per cent relative humidity. These environmental conditions were chosen as they cause a definite thermal stress, but are not too severe.

After one week of exposure the animals were clipped with a hair clipper used regularly in clipping dairy cows. This type of clipper was preferred in order to simulate practices and conditions generally encountered in the dairy industry.

The reactions studied included daily measurements of rectal temperature, respiration-rate, ventilation-rate, tidal air, respiratory vaporization, heat production by the open circuit method[3], water and feed consumption. The surface radiant temperature was measured (using a Hardy dermal radiometer) on five regions of the body, once on the unclipped animals and once after clipping. Total vaporization measurements by the tent method[4] were made twice before clipping and twice afterwards. A fixed schedule of management and timing of measurements was observed.

The averages for the reactions measured are given in Table 1.

The rectal temperature remained practically the same in spite of the clipping. There were drops in respiration-rate, total vaporization, ventilation-rate, pulmonary vaporization, and a similarly non-significant increase in tidal air volume. Although statistically non-significant, the occurrence of all these changes may indicate some alleviation of the thermal stress.

The surface temperature increased by 0·46 deg. F. after clipping, an increase that was highly significant statistically. The loss of heat varies with the temperature gradient between the surface and air temperatures. The increase in the temperature gradient may be estimated by the ratio:

$$\frac{\text{surface temp. after clipping} - \text{air temp.}}{\text{surface temp. before clipping} - \text{air temp.}} = \frac{95 \cdot 95 - 89 \cdot 1}{95 \cdot 49 - 89 \cdot 1} = 1 \cdot 072$$

Therefore, an approximate increase of about 7 per cent may be assumed to have occurred in the temperature gradient, and probably the coefficient of insulation decreased too.

It is noteworthy that this increase in loss of heat was not reflected in a drop in the rectal temperature, although the rectal temperature is a fairly accurate estimate of the deep-body temperature[5].

The animals reacted to the increase in dissipation of heat by increasing their production of heat and consumption of food by a statistically significant amount.

It is generally accepted that the production of heat is closely related to the level of productivity.

The rectal temperature of 103° F., although markedly higher than that accepted as normal, did not inhibit an increase in the production of heat when the loss of heat was accelerated. This indicates the equality of production and loss of heat, as well as the independence of rectal temperature and heat production within the physiological limits of this experiment. On the other hand, this experiment indicates that the peripheral insulation may well have an important place in determining the expression of the full potential heat production of fur-bearing homœothermic animals.

Grateful acknowledgments are made to the Jewish Agricultural Society, New York, for the fellowship granted to one of us (A. B.) and to the members of the University of Missouri Climatic Project for their co-operation.

A. Berman

Faculty of Agriculture,
Hebrew University,
Rehovot, Israel.

H. H. Kibler

Department of Dairy Husbandry,
University of Missouri,
Columbia, Missouri.

Oct. 7.

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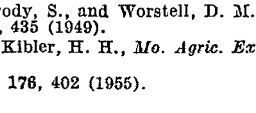
Pharmacological and Toxicological Properties of 5-Benzylidenerhodanine

In connexion with the study of the chemistry of 5-benzylidenerhodanine (5-benzylidene-2-thiooxo-4-oxothiazolidines) by A. Mustafa *et al.*[1] the pharmacological action of these compounds exemplified by 5-benzylidenerhodanine (I) has now been investigated.



(I)

5-Benzylidenerhodanine (mol. wt. 221; m.p. 204° C.) is a yellow, crystalline, odourless substance. It is soluble in aqueous sodium bicarbonate solution, but when warmed with dilute aqueous alkali the heterocyclic ring is opened with the formation of phenylthiopyruvic acid[2–4]. It is soluble on warming with propylene glycol, and its solution is stable to light and air.

Concerning the pharmacological activity it seems, so far as we are aware, that the biological actions of 5-benzylidenerhodanine have not been investigated, except for the observations of Mazzanti[5] on its action on the functional activity of the pancreas. Mazzanti found that it does not affect the level of the blood sugar in rabbits in a dose of 190 mgm./kgm. body-weight for two days.

In these studies the compound was dissolved in 5 per cent sodium bicarbonate solution. The solubility is accelerated by mild heating, a clear yellow solution being obtained. 1 gm. dissolves in about 200 ml. of 5 per cent sodium bicarbonate solution.

Blood-pressure studies were conducted on 5 dogs under ether anæsthesia, and on 3 dogs under chloralose anæsthesia. Carotid blood pressures were recorded with a mercury manometer. Injections were made into the saphenous vein. In a dose of 133 mgm./kgm. body-weight, a rise of blood pressure of about 40 mm. of mercury was recorded. This hypertensive action was of short duration (5 min.). An injection of an equal volume of the solvent alone (5 per cent sodium bicarbonate) produced a rise in blood pressure of about 10 mm. of mercury, After blocking the autonomic ganglia with pentamethonium, the compound still exerted its effect on pressure. It was noticed that after ganglionic blockade the pressor activity was much intensified; but the duration of action remained the same. After the administration of phentolamine, the same dose of 5-benzylidenerhodanine produced an elevation of blood pressure of about 30 mm. of mercury.

The rate and amplitude of respiration were increased during the vascular actions of the drug.

In two of the dogs used in the foregoing studies, electrocardiogram leads I, II and III were taken under anæsthesia and shortly after the injections of 5-benzylidenerhodanine. There appeared to be no significant difference in the regularity or form of the tracing in any animal in any lead.

A very dilute solution of 5-benzylidenerhodanine was prepared (1 in 1,000) and perfused through a toad's heart *in situ*. Ten experiments were carried out. There appeared to be reduction in both the rate and force of contraction, The heart recovered after washing. When the heart was nicotinized with 1 per cent nicotine solution to block the parasympathetic ganglia located in the heart, the drug still produced a cardiac inhibitory action.

A rabbit's heart was extirpated after killing the animal by cerebral contusion. The defibrinated blood was mixed with Locke–Ringer's solution and perfused through the aorta. Tracings were made of the heart-beat. At intervals of 5 min., 5 ml. of 1 in 1,000 solution of 5-benzylidenerhodanine in Locke–Ringer's solution were introduced into the perfusion fluid. Five experiments were made, and in each case the effect upon the rabbit's heart coincided with the results obtained on the toad's heart *in situ*, namely, there is depression of both rate and force of cardiac contractions.

The effect of 5-benzylidenerhodanine on isolated strips of rabbit jejunum was determined. The strips were suspended in oxygenated Locke's solution at a constant temperature of 37° C. At a concentration of 1 in 2,000, 5-benzylidenerhodanine produced a contraction of the normal jejunum which is followed by depression, from which the intestine could be recovered by washing. If nicotine was added to the bath (1 per cent) to paralyse the parasympathetic ganglia and then 5-benzylidenerhodanine added, there was also an initial stimulation of brief duration which was followed by depression. Isolated strips were obtained from virgin rats. They were suspended in oxygenated Locke's solution and kept at a constant temperature of 37° C. In a concentration of 1 in 2,000, 5-benzylidenerhodanine produced a decrease in the uterine tonus with a diminution of the individual contractions. After the uterine strips were first treated with ergatoxine, 5-benzylidenerhodanine still produced a depression in tonus.

The pharmacological activity of 5-benzylidenerhodanine and of 4-benzylidene-2-thiooxo-5-oxothiazolidine will be described elsewhere.

Salah A. Tawab
Ahmed Mustafa
A. F. A. Mawgoud Shalaby
Departments of Pharmacology and Chemistry,
University of Cairo.
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The γ-Aminobutyric Acid and Glutamic Acid Content of Brains of Rats treated with Toxopyrimidine

In 1939, Abderhalden[1] found that the administration of the pyrimidinic moiety of the thiamine molecule (2-methyl, 4-amino, 5-oxymethylpyrimidine; toxopyrimidine) to rats reared on suitable diet caused convulsions and death in a few hours. Afterwards, Makino *et al.*[2,3] showed that the convulsive action of the toxopyrimidine could be overcome by administering pyridoxamine, and Makino and Koike[4,5] gave enzymatic evidence of the competitive antagonism between vitamin B_6 and toxopyrimidine showing the *in vitro* inhibition of tyrosine-decarboxylase by toxopyrimidine phosphate.

The role of pyridoxine deficiency or antagonists in the seizure mechanisms has been well established[6,7]. Tower[8] emphasized the importance of the glutamic–γ-aminobutyric acid system in neuronal activity and the close connexion between the dysfunction of this system and the onset of convulsions.

Since toxopyrimidine, which *in vitro* has an anti-pyridoxine action, produces *in vivo* epileptic seizures, it seemed desirable to study the *in vivo* action of this substance on the glutamic-γ-aminobutyric system of the brain, in relation to the activity of glutamic-decarboxylase.

Therefore, we determined the γ-aminobutyric acid and glutamic acid contents of the brain of rats treated both with toxopyrimidine and toxopyrimidine followed by pyridoxamine.

Male albino rats, weighing 60–70 gm., placed for 7 days on a diet deficient in vitamin B_6 similar to that described by Makino *et al.*[2], were intraperitoneally injected with toxopyrimidine (125 μgm./gm. body-weight), dissolved in saline. At 90–120 min. after the injection, that is, after the onset and several replications of the convulsive seizures, the animals were killed by decapitation. The pyridoxamine (62 μgm./gm. body-weight) was injected in the peritoneum of rats showing seizures, and the animals were killed at different times after the

Table 1. γ-AMINOBUTYRIC ACID AND GLUTAMIC ACID CONTENT OF THE BRAIN OF RATS TREATED WITH TOXOPYRIMIDINE

No. of experiments	Condition	Content (mgm./gm.)	
		γ-Amino-butyric acid	Glutamic acid
11	Treated	$0{\cdot}161 \pm 0{\cdot}007$	$1{\cdot}59 \pm 0{\cdot}059$
16	Controls	$0{\cdot}210 \pm 0{\cdot}004$	$1{\cdot}65 \pm 0{\cdot}033$
12	Normals	$0{\cdot}203 \pm 0{\cdot}003$	$1{\cdot}53 \pm 0{\cdot}028$

Table 2. γ-AMINOBUTYRIC ACID AND GLUTAMIC ACID CONTENT OF THE BRAIN OF RATS TREATED WITH TOXOPYRIMIDINE AND PYRIDOXAMINE

No. of experiments	Condition	Hours after vitamin B_6 injection	Content (mgm./gm.)	
			γ-Amino butyric acid	Glutamic acid
11	Treated	0	$0{\cdot}161 \pm 0{\cdot}007$	$1{\cdot}59 \pm 0{\cdot}059$
8	Treated + B_6	1½	$0{\cdot}175 \pm 0{\cdot}005$	$1{\cdot}49 \pm 0{\cdot}074$
4	Treated + B_6	3½	$0{\cdot}203 \pm 0{\cdot}012$	$1{\cdot}56 \pm 0{\cdot}005$
4	Treated + B_6	6	$0{\cdot}199 \pm 0{\cdot}015$	$1{\cdot}47 \pm 0{\cdot}170$
12	Normals	0	$0{\cdot}203 \pm 0{\cdot}003$	$1{\cdot}53 \pm 0{\cdot}028$

injection (Table 2), when all convulsive symptoms had disappeared.

The controls received the deficient diet for 7 days, and the normal rats were kept on the complete diet used by us in breeding. In every case, after decapitation, the brain was removed very quickly, weighed and homogenized in 75 per cent ethanol in centrifuge tubes.

The γ-aminobutyric acid and glutamic acid were extracted from the brain following the method of Roberts and Frankel[9] with slight modifications.

The extract was applied on a wide sheet of Whatman No. 1 filter paper using an 'Agla' micrometer syringe. Four controls were run in each chromatogram. The developing solvent for the descending chromatography was a freshly prepared solution containing *iso*propanol/acetic acid/water (100 : 24 : 20)[10]. Chromatography continued for 40–44 hr. at $20 \pm 2°$ C. The spots were revealed and eluted following the method of Montreuil and Khouvine[11]. The optical densities were read in a Beckman spectrophotometer model *DU*, at 505 mμ, using 1-cm. cuvettes.

The results summarized in Table 1 show that, while the 7 days of vitamin B_6 deficiency failed to modify the γ-aminobutyric acid cerebral content, toxopyrimidine, which produced serious epileptic seizures, caused a statistically significant ($t = 6{\cdot}38$; $P < 0{\cdot}001$) decrease of this amino-acid in comparison with the controls. No detectable modification, on the contrary, was found in the glutamic acid content.

The administration of pyridoxamine to the epileptic rats, which stopped the convulsions in about 1 hr., did not modify the γ-aminobutyric acid cerebral content so quickly. In fact, the normal level in the brain was attained only after 3½ hr. from the vitamin injection, although at 1½ hr. some increase was already noticeable (Table 2).

The decrease of the γ-aminobutyric acid content of the brain, after administration of toxopyrimidine, is likely to be related to the inhibition of the glutamic-decarboxylase by toxopyrimidine. Work on this is now in progress in our laboratory.

It is more difficult to explain the finding of no modification in the glutamic acid content of the brain. Tentatively, we can assume that the amount of this acid derived from the inhibition of the glutamic-decarboxylase was further metabolized to support the energy needs during epileptic seizures[12], so disappearing from the tissue.

G. RINDI
G. FERRARI

Institute of Human Physiology,
University of Pavia.

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Effect of Dietary Protein on the Severity of Experimental Mouse Hepatitis

THERE are few observations concerning the effect of nutritional state on human hepatitis. These have produced conflicting results[1,2]. As all attempts to culture the virus of human infectious hepatitis have been unsuccessful[3] the effect of dietary deficiency on mouse hepatitis was investigated. *M.H.V.*3 virus isolated by Dick, Niven and Gledhill[4] was selected. This virus is uniformly fatal to weanling mice but mortality decreases with age. Swiss Webster strain mice (Budd Mountain Farm, Chester, New Jersey) were used. The severity of *M.H.V.*3 infection is enhanced by *Eperythrozoon coccoides*. Peripheral blood films from the experimental mice showed they did not carry *Eperythrozoon coccoides*.

It has been shown that choline deficiency does not affect the course of mouse hepatitis virus infection[5]. During this work it was noticed that the mortality of mice on some of the experimental diets was much higher than that of mice on a standard laboratory diet. The standard laboratory diet was 'Purina Chow', which is stated by the manufacturer to contain 26·8 per cent protein. The experimental diets contained considerably less protein.

The effect of two diets differing in protein content was therefore studied. One experimental diet consisted of (per cent by weight):

Casein	26
Dextrin	62·5
Lard	6
Cod liver oil	1
Salt mixture No. 2 U-S-P.	3
Vitamin mixture (ref. 6)	1
Alpha tocopherol	0·01
Choline	0·5

The other diet contained 8 per cent casein and 80·5 per cent of dextrin, but was otherwise identical in composition. Both diets were adequate for growth, but weight gain was more rapid in the animals on the high protein diet.

In one typical experiment two groups of 30 mice, aged 32 days, which had been on the experimental diets for eleven days, were inoculated intraperitoneally with 0·1 ml. of a 1 per cent mouse liver suspension obtained from mice infected with *M.H.V.*3 virus.

Table 1. Number of Mice dying each day after injection of *M.H.V.*3 Virus

	Day 1	2	3	4	5	6	7	8	9	10	11	12	Total deaths
High protein diet: (30 mice)	0	0	0	3	3	3	0	0	0	0	0	0	9
Low protein diet: (30 mice)	0	0	0	5	8	5	1	0	0	0	0	0	19

The number of mice dying each day after injection is shown in Table 1. The mortality rate of mice on the high protein diet was thus approximately half that of mice on the low protein diet. This difference is statistically significant ($\chi^2 = 5 \cdot 6$, $P < 0 \cdot 02$). It is concluded that a decrease in protein content affects adversely the mortality from virus hepatitis in mice. This finding confirms that a high protein diet is protective against hepatotoxic agents[7] and is in keeping with observations suggesting that dietary deficiency may be harmful in human hepatitis[2].

Mirick and Leftwich[8] found that a prolonged deficiency of pyridoxine adversely affected the resistance of mice to pneumonitis virus. In their paper they review a few previous similar observations. One of these was made by MacCallum and Miles[9], who inoculated material from patients with infectious hepatitis into rats. They produced a transmissible disease in protein-deficient rats but not in well-nourished animals. In view of subsequent work on infectious hepatitis it seems likely that in their findings, as in the present investigation, a rodent virus rather than a human virus was causing the experimental hepatitis. While the clinical picture of many virus diseases can be altered by dietary deficiency[10] the usual effect is to render animals on deficient diets relatively insusceptible. The present observations, like those of Mirick and Leftwich[8], constitute an exception to this rule.

This work was supported by a grant from the National Research Council of Canada.

Boris Ruebner
James L. Bramhall

Department of Pathology,
Dalhousie University,
Halifax, Nova Scotia.

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Oxidative Metabolism of Cartilage

Although utilization of oxygen by mature cartilage is very low, with Qo_2 values ranging between 0 and 0·68[1–5], studies by Rosenthal, Bowie, and Wagoner[6] and Boyd and Neuman[7] have shown that embryonic cartilage utilizes significantly greater amounts of oxygen (Qo_2, 2·2). Paradoxically, although dehydrogenases customarily mediated via cytochrome oxidase (that is, succinic and isocitric dehydrogenases) have been identified in both mature and embryonic cartilage[1,8], until now the biochemical demonstration of cytochrome oxidase activity in cartilage had not been accomplished.

Table 1. Cytochrome Oxidase in Cartilage Homogenates

(*a*) Oxidation of reduced cytochrome *c* at 550 mμ

Specimen	Mgm. (dry weight) tissue per cuvette	Decrease in absorbance in 3-min. interval
Limulus	0·46	−0·102
Busycon	0·78	−0·185
Squalus	1·10	−0·130

(*b*) Manometric oxidation of hydroquinone in system limiting for cytochrome oxidase

Specimen	Mgm. (dry weight) tissue per Warburg vessel	Observed oxygen uptake (μl./hr.)	Qo_2 (μl./hr./mgm. dry tissue)
Limulus	4·4	44	10·0
Busycon	8·1	76	9·4
Squalus	12·7	95	7·9

In this communication cytochrome oxidase activity in cartilage from invertebrate and vertebrate forms, and the existence in cartilage of substances which inhibit cytochrome oxidase activity are reported.

Since cytochrome oxidase is by definition[9] the enzyme which oxidizes reduced cytochrome *c*, this ability was the first criterion used in demonstration of the enzyme in cartilage.

In Table 1*a* are results from typical experiments demonstrating the oxidation of reduced cytochrome *c* by gill cartilage homogenates from young specimens of *Limulus* (horseshoe crab), *Squalus* (dog-fish), and odontopore cartilage from *Busycon* (whelk). Autooxidizability of cytochrome *c* and settling of homogenates were eliminated in these experiments. Boiled homogenates were inactive. The ability of homogenates to oxidize reduced cytochrome *c* was inhibited 80 and 45 per cent by 10^{-4} *M* cyanide and azide, respectively. These results represent the first spectrophotometric demonstration of the oxidation of reduced cytochrome *c* by cartilage from any source.

In Table 1*b* results are given for the manometric determination of cytochrome oxidase activity[10] using hydroquinone as substrate and added cytochrome *c*. Boiled homogenates were inactive. Without exogenous cytochrome *c* enzymatic hydroquinone oxidation was not demonstrable. 10^{-4} *M* cyanide and azide inhibited 55 and 34 per cent, respectively. The Qo_2 values, ranging between 7·9 and 10·0, are the highest thus far reported for cartilage tissue.

The occurrence of negative and questionable experiments during the above studies led to the conjecture that cartilage homogenates might contain substances which inhibit oxidative metabolism. Preliminary evidence for the existence of such inhibitors was found in the studies of cartilage metabolism by Lutwak-Mann[11]. Accordingly, experiments were performed to test this hypothesis. In Fig. 1 is depicted the effects of addition of *Limulus* gill cartilage upon cytochrome oxidase activity of rat-heart-muscle homogenates. As the quantity of cartilage homogenate added to the system was increased, the oxygen utilization of a given amount of heart homogenate decreased. Similar inhibitory actions were found in cartilage from the whelk, dog-fish, rat, and dog, using both manometric and spectrophotometric assays for cytochrome oxidase activity. Neither cytochrome oxidase activity nor the existence of inhibitory substances have been detected in head cartilage from *Loligo* (squid), which

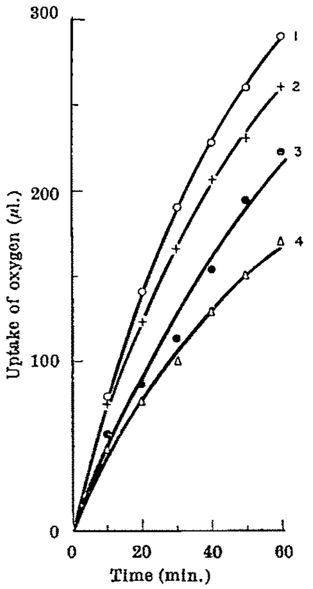

Fig. 1. Effect of adult *Limulus* gill cartilage on hydroquinone oxidation via cytochrome oxidase of rat-heart homogenate. Curve 1, 1·0 ml. rat-heart homogenate in total volume of 3·0 ml. Curves 2, 3 and 4 contain in the same total volume 1·0-ml. rat-heart homogenate, plus 0·1, 0·5 and 1·0 ml., respectively, of cartilage homogenate

has also been studied. Full details of the above experiments are being prepared for publication elsewhere.

Since cartilage cells 'degenerate' as the tissue matures (even in young animals), one reason for the past inability to detect cytochrome oxidase in cartilage may be such cell degeneration. Another reason, now evident and requiring more detailed study and consideration, appears to be the presence in cartilage of inhibitors of oxidative activity.

PHILIP PERSON
ALBERT FINE

Special Dental Research Laboratory,
Veterans Administration Hospital, Brooklyn,
New York, and
Marine Biological Laboratory, Woods Hole, Mass.

Dec. 1.

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Chemical Excitation of Spinal Neurones

THE presence of comparatively large quantities of glutamic acid in brain together with the conflicting evidence of the effects of glutamic acid administration[1] have led to an investigation of the effects of this and related monoamino-dicarboxylic acids upon spinal cells. When applied ionophoretically, both glutamic and aspartic acids were very effective in evoking repetitive discharges from all types of interneurones located in the dorsal horn and intermediate nucleus of the spinal cord of the cat. For example, Fig. 1*A* illustrates the spike potentials of a dorsal horn cell activated orthodromically and recorded by means of one barrel of a double-barrelled electrode. The background discharge-rate of this cell was zero (Fig. 1*B*). Several seconds after a current of 120 mμ amp. was employed to pass anion from a saturated solution of the sodium salt of L-glutamic acid (*p*H 8·5) in the other barrel of the electrode, the cell fired with a frequency of 100 per sec. (Fig. 1*C*), and 5 sec. later this had risen to 440 per sec. (Fig. 1*D*). 1 sec. after the current was stopped, the cell ceased firing. Control experiments indicated that this excitatory action was due specifically to the amino-acids and not to other effects arising from the passage of the ionophoretic currents.

When these substances were similarly applied to the surface of motoneurones from the extracellular barrel of a co-axial electrode, the intracellular electrode recorded a membrane depolarization which, when summed with the depolarization arising either from current passed through the intracellular electrode or from sub-threshold synaptic excitation, fired the cell. Intracellularly recorded excitatory and inhibitory post-synaptic potentials of motoneurones were found to be slightly changed by the extracellular ionophoretic application of aspartic and glutamic acids. These effects would be expected to arise as a result of the concurrent depolarization[2].

Renshaw cells, activated in the typical manner by acetylcholine applied ionophoretically from one barrel of a multibarrel electrode, were also excited by glutamic or aspartic acids applied in a similar fashion

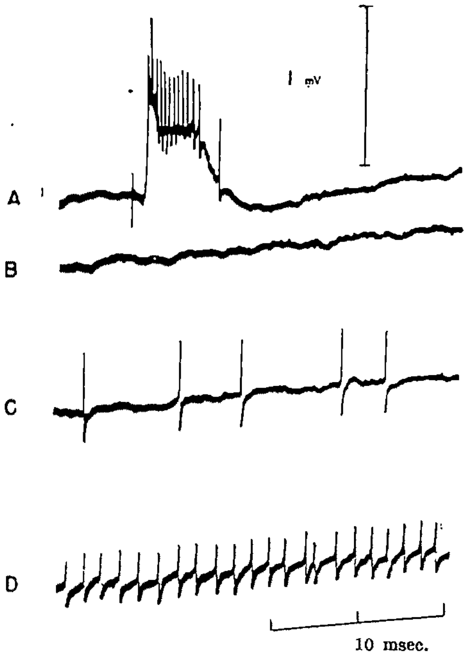

Fig. 1. Spike potentials of an interneurone located in the dorsal horn of the spinal cord and recorded from the sodium chloride containing barrel of a double barrel electrode. *A*, stimulation of the superficial peroneal nerve; *B*, background discharge in the absence of stimulation; *C* and *D*, recorded as in text during the passage of glutamic acid from the other barrel of the electrode into the extracellular environment of the cell. Voltage calibration 1 mV. for all records. Time, 10 msec.

from another barrel. Since neither interneurones nor motoneurones responded to acetylcholine applied ionophoretically, it appears that these amino-acids are capable of exciting neurones normally activated synaptically by different transmitter agents.

Consequently, these observations suggest that glutamic and aspartic acids have a non-specific excitatory action upon certain spinal neurones, a finding which is in accordance with earlier observations upon the non-specific depressant actions of the related monoamino-monocarboxylic acids[4]. These results provide a possible explanation of the convulsive disorders associated with disturbances of glutamic and aspartic acid metabolism[5].

D. R. CURTIS
J. W. PHILLIS
J. C. WATKINS

Department of Physiology,
Australian National University,
Canberra.
Nov. 17.

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Anti-Tumour Activity of 5-Mercaptouracil

5-MERCAPTOURACIL, a structural analogue of thymine, was synthesized several years ago[1,2]. This compound (and its disulphide) inhibited the growth of *Lactobacillus leichmannii* at 1–3 µgm./ml. concentration, and this inhibition could be reversed 'competitively' with thymine. It was tested in several experimental mouse tumours; in some cases, it caused tumour inhibition of borderline significance, at less than the maximum tolerated dose[3].

The effect of 5-mercaptouracil on the biosynthesis of deoxyribonucleic acid was studied, by microbiological inhibition analysis techniques, in relationship with other antimetabolites[4]; this work was part of a research programme aimed at the inhibition of biosynthesis of deoxyribonucleic acid at several consecutive and/or alternative reaction steps. It was concluded that there are at least two alternative pathways for the biosynthesis of 'DNA-thymine', only one of which (Fig. 1, *a* + *b*) involves the utilization of thymine itself. The ability to convert thymine to thymidine (step *b*) which, at least in the case of *L. leichmannii*, requires either the catalytic action of vitamin B_{12} or the presence of deoxyribosides, varies from organism to organism; it may be expressed in a quantitative manner by a 'conversion ratio'[4], high for *L. leichmannii* (1 : 5) and low for *L. arabinosus* (1 : 450). This conversion ratio is increased by excess thymine ('mass action'), decreased by thymine antagonists, and not directly affected by anti-folic or anti-uracil compounds. Although the latter antimetabolites do inhibit the preceding (*a*) step (that is, the conversion of uracil to thymine), this step is altogether by-passed in the presence of exogenous thymine.

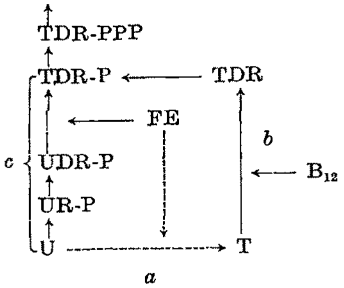

Fig. 1. Pathways of DNA-thymine biosynthesis from uracil and thymine. Abbreviations: U, uracil; UR-P, uridylic acid; UDR-P, deoxyuridylic acid; T, thymine; TDR, thymidine; TDR-P, thymidylic acid; TDR-PPP, thymidine triphosphate; DNA-T, deoxyribonucleic acid-thymine; FE, folic acid (tetrahydrofolic acid) enzyme; B_{12}, a 'vitamin B_{12} enzyme'

The alternative (*c*) pathway requiring the folic acid (tetrahydrofolic acid) enzyme is strongly inhibited by anti-folic and anti-uracil compounds, and is unaffected by thymine or thymine antagonists. Some thymine antagonists, however, may act here as 'substitute metabolites'. 5-Bromouracil, for example, actually reverses the inhibitory action of anti-folic and anti-uracil compounds[4]. More recent work by Friedkin[5] and by Kornberg[6] established the intermediate reaction steps along route *c* of our scheme[4] in the manner indicated in Fig. 1.

On the basis of this more detailed representation of route *c*, it is now possible to understand, by analogy, the corresponding transformations of 5-bromouracil (by the enzymes of route *c* but bypassing the methylation step) which lead to its incorporation into deoxyribonucleic acid.

In contrast, 5-mercaptouracil does not seem to act as a 'substitute metabolite' along route *c*; and, probably by inhibiting the alternative *a* + *b* pathway at step *b*, it seems to potentiate the inhibitory action of anti-folic and anti-uracil compounds. This was found to be the case in various microbiological systems (results will be reported elsewhere); particularly strong synergism was found between 5-mercaptouracil and 2,4-diamino-6,7-dimethyl-2,4-deoxyalloxazine[7] in inhibiting the growth of *L. arabinosus*.

The synthesis of 5-fluorouracil by Heidelberger and his co-workers[8] provided a most effective anti-uracil compound which is far superior to 5-nitrouracil used in our earlier work[4]. The transformations of 5-fluorouracil (along route *c*) to 5-fluorodeoxyuridylic acid, and its mechanism of action via inhibition of the methylation step, have been described[9]. As it blocks the same reaction step of route *c* which requires the folic acid (tetrahydrofolic acid) enzyme, it is not surprising that there is no synergism between 5-fluorouracil and folic acid antagonists[10].

5-Fluorouracil is a powerful inhibitor of several mouse and rat tumours[8]. These animals are known to utilize thymine very poorly[11]; instead, route *c* appears to be their main pathway of deoxyribonucleic acid–thymine biosynthesis. However, if route *c* is blocked by 5-fluorouracil, route *b* becomes important, as indicated by a significant increase in the effectiveness of 5-mercaptouracil as an inhibitor of tumour growth. This effect was demonstrated in several mouse tumours. The results of the sarcoma 180 and adenocarcinoma 755 experiments are summarized in Table 1 (detailed results will be published elsewhere).

The results indicate that 5-mercaptouracil, in the presence of a relatively low dosage-level of 5-fluorouracil, causes significant inhibition of tumour growth. This fact is of potential chemotherapeutical interest

Table 1. Inhibitory Action of Combinations of 5-Fluorouracil (FU) and 5-Mercaptouracil (MU) in Animal Tumours

Tumour	Compound	Dose (s.c.) (mgm./kgm./day)	Mean tumour weight treated/control
Sarcoma 180	FU	10	* 0·61
	MU	5	0·76
	FU MU	10 5	0·22
Adenocarcinoma 755	FU	10	† 0·49
	FU	25	0·47
	MU	5	0·94
	MU	50	0·93
	FU MU	10 5	0·38
	FU MU	10 50	0·38
	FU MU	25 5	0·28

* Mean, calculated from mean treated/control results of four experiments, totalling 35 mice for each treatment.

† Mean treated/control results of one experiment with 10 mice in each group.

because: (1) it offers the possibility of reducing the clinically effective dosage of 5-fluorouracil from its present toxic level[12]; (2) since, on the basis of available although indirect evidence[13,14], the thymine (vitamin B_{12}-catalysed) pathway is more important in humans than in mice, 5-mercaptouracil may be relatively more effective as a therapeutic agent.

We are grateful to Dr. J. A. Aeschlimann and Dr. R. Duschinsky, of Hoffmann-La Roche, Inc., for gift samples of the 5-fluoropyrimidine compounds.

THOMAS J. BARDOS

Research Division,
Armour and Co.,
Chicago 9.

ALBERT SEGALOFF

Alton Ochsner Medical Foundation
and Department of Medicine,
School of Medicine,
Tulane University,
New Orleans.

JULIAN L. AMBRUS

Roswell Park Memorial Institute
and University of Buffalo,
Medical and Graduate Schools,
Buffalo, New York.

Dec. 11.

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An Equation for the Flow of Blood, Plasma and Serum through Glass Capillaries

WHEN blood flows through narrow tubes, the larger suspended particles tend to accumulate in the centre, leaving a zone of plasma near the walls. In mammals, the red cells are smaller than the leucocytes but, when associated in groups (rouleaux or clumps), they will tend to replace the leucocytes in the centre, thus altering the distribution of concentration. This means that Poiseuille's fourth-power radius law fails to hold[1]. Several authors, notably Fåhraeus[2], have stressed the importance of this in large and small vessels *in vivo*. The significance of intravascular clumping or 'sludging' has been widely discussed by Knisely and his school[3] (see also ref. 4).

A quantitative measure of the changes in apparent viscosity, defined as shear stress (τ) divided by shear rate (D), when this is not independent of D, is not difficult so long as the curves plotting D against τ (known as 'flow curves') are straight, as is the case with soil and most clay pastes. Schofield and Scott Blair[5], who studied these systems, introduced the term 'sigma phenomena' to describe all deviations from the fourth-power radius law, whatever their cause. For blood, no equation would seem yet to have been proposed which gives a satisfactory linear relation by means of which the sigma phenomena for varying capillary radii can be quantitatively expressed.

Copley, Krchma and Whitney[6] came near to finding a solution so long ago as 1942. They pointed out that flow-curves for blood are nearly straight, but give an intercept on extrapolation to the stress or pressure axis, that is, blood approximates to Bingham's well-known equation in which D is proportional to $\tau - \tau_0$ where τ_0 is a yield-value. Since the curves are not quite straight, however, they suggested that "a more exact relationship might be that of Herschel and Bulkley[7] or some similar variation". This implies plotting log $(\tau - \tau_0)$ against log D; but the results have not proved altogether satisfactory.

Recently, Casson[8,9], basing his calculations on certain assumptions concerning the magnitude of inter-particle forces and disruptive stresses in chain-like floccules present in varnishes and printing inks, has derived a very simple equation to replace that of Bingham:

$$\tau^{1/2} = k_0 + k_1 D^{1/2}$$

which reduces to the Newtonian law when $k_0 = 0$.

Steiner[10] has recently shown that this equation holds over a wide range of shear-rates for melted chocolate and that it makes possible a satisfactory comparison of data from very different types of viscometer, for this material.

Mr. F. A. Glover and I have recently made a number of measurements on the viscosity of cows' blood (treated with anticoagulant) and of its plasma and serum in a series of capillary viscometers with diameters ranging from 0·1 to 0·6 mm. and have confirmed the presence of marked sigma phenomena, especially in the narrower tubes, though plasma and serum are occasionally so nearly true fluids that the anomalies are sometimes too small to measure. Dr. A. L. Copley and his staff have also kindly made available to us a large number of similar results on both human and bovine blood. Not many suitable results appear in the literature, but figures from the works of Kümin (cows' blood)[11], Suter (defibrinated

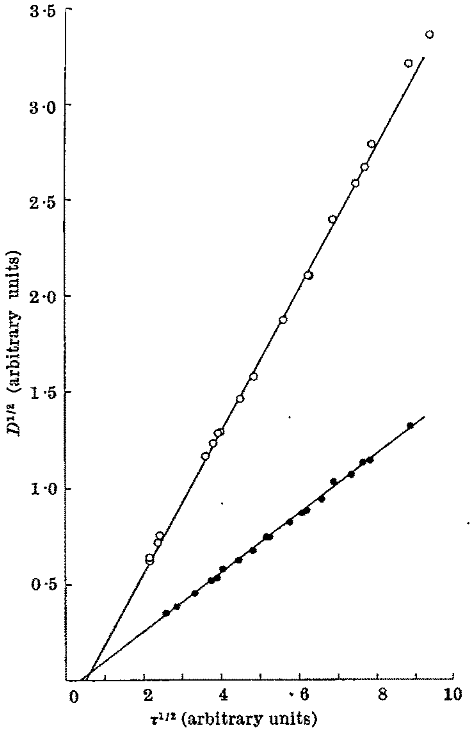

Fig. 1. Two samples of cows' blood, after Kümin

ox blood)[12] and Bircher, cited by Müller (pig's blood)[13], show remarkable linearity when $P^{1/2}$ is plotted against $V^{1/2}$, except perhaps at the highest rates of shear (P, pressure ; V, volume flow/sec.).

A similar linearity was found for all the unpublished results available. It has not always been possible to convert the published data so as to plot τ against D, but this does not affect the straightness of the curves for each individual capillary. By way of illustration, two curves are shown from Kümin (Fig. 1) and one curve from an experiment carried out by Mr. Glover, on human blood supplied by Dr. Copley (Fig. 2). In Fig. 1 a few points, queried by Kümin, are omitted and the units are arbitrary, nor are they comparable for the two samples. In Fig. 2 absolute units are used.

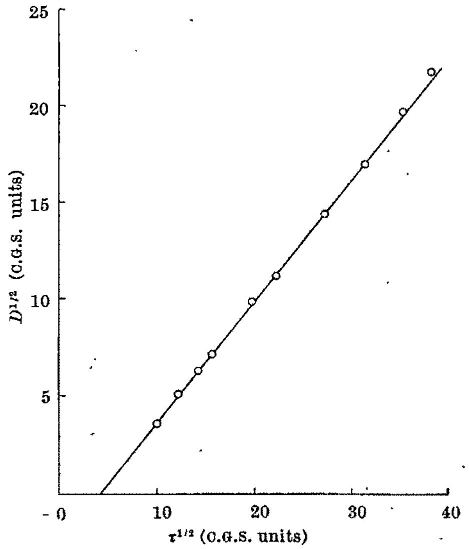

Fig. 2. Healthy human blood

For wide capillaries (diameter > 0·15 mm.) the slopes and intercepts of the $\tau^{1/2}/D^{1/2}$ curves do not differ greatly but, in narrower tubes, marked changes occur, especially in the values of k_0, which may thus be directly related to the radius in order to measure the extent of the sigma-phenomenon.

The results of these experiments will be published in full elsewhere. The purpose of the present communication is to show that a plot of $\tau^{1/2}$ against $D^{1/2}$ for blood, plasma and serum of several species, gives excellent straight lines which extrapolate to the origin only in the special case where deviations from Newtonian behaviour are too small to measure, thus giving a simple quantitative expression for the extent of the very important sigma phenomenon.

I am indebted to my colleague Mr. F. A. Glover, who has done many of the experiments, and to Dr. A. L. Copley, director of experimental research on vascular diseases at Charing Cross Hospital, for his generous supply of data and for many helpful discussions, and to Dr. N. Casson for the loan of a proof copy of his chapter in a forthcoming book.

G. W. Scott Blair

National Institute for Research in Dairying,
University of Reading.
Jan. 13.

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Effect of a Sympathomimetic Agent (Methoxamine Hydrochloride) on Growth of Hair in the House Mouse (*Mus musculus*)

The association of an intense capillary network with regions of active hair growth in the rat[1] suggests that blood supply plays an important part in the mechanism of the hair cycle in rodents. It was therefore of interest to test the effects of a vasoconstrictor sympathomimetic drug, methoxamine hydrochloride (β-hydroxy-β(2,5-dimethoxyphenyl) *iso*propylamine) on the time taken for the spread of the hair wave and on the amount of hair grown during the cycle.

The offspring of $CBA \times A^w$ females backcrossed to A^w males were weaned and the dorsal hair clipped at 21 days of age. A small patch on the head was also clipped. These mice were then weighed daily, and the areas of new growth, as shown by the appearance of yellow hair tips, were noted. The back was divided into six regions for the spread of the hair wave and the date recorded when hair appeared. The regions in order of appearance of hair were shoulder, mid-side, flank, anterior dorsal, mid-dorsal

Table 1. THE EFFECT OF DAILY INJECTIONS OF METHOXAMINE ON HAIR GROWTH

	n	Age (days) wave initiated		Duration (days) hair wave		Body-weight* (gm.)		Regions showing growth*		Hair-weight (mgm.)	
		Mean	*S.D.*	Mean	*S.D.*	Mean	*S.D.*	Mean	*S.D.*	Mean	*S.D.*
Males											
Controls	22	27·5	2·02	6·3	3·11	17·6	1·84	3·18	1·79	162	22·9
Methoxamine	12	28·8	4·43	7·1	2·84	17·2	2·89	2·17	2·08	116	44·6
Significance of difference		n.s.		n.s.		n.s.		0·1–0·2		< 0·001	
Females											
Controls	12	30·3	2·24	11·1	4·38	17·0	1·13	2·40	1·00	147	18·6
Methoxamine	9	31·8	1·76	20·2	9·35	17·8	2·30	2·00	0·87	90	17·8
Significance of difference		0·1–0·2		0·01–0·001		n.s.		n.s.		< 0·001	

* Males, 30 days of age ; females, 35 days of age.

and posterior dorsal. The majority of mice followed this cycle, which is described by Borum[2] as type III. The mice were shaved again about 12 days after growth commenced in the final stage and the weight of hair grown during the second cycle on the back was thus obtained. The initial stages of the third cycle rarely started before a further 12 days.

Methoxamine injections were given daily from weaning until the shaving at the end of the cycle or, if later, when hair appeared on the head. Constant doses were given subcutaneously throughout. Dose-rates of 0·15 and 0·25 mgm. in 0·05 ml. were used with both males and females and additional males were given 0·35 mgm. daily. Control animals were injected with 0·05 ml. of physiological saline.

The results shown in Table 1 were those from all treated animals of each sex grouped together because differences attributable to the different dose-rates could not be detected. The duration of the hair wave was taken as the time from the first appearance of new hairs to the appearance of hairs in the final area on the back.

The treatment decreased the weight of hair grown by mice of both sexes and also increased the duration of the hair wave of the females. A retarding of the stage of the hair wave at 30 days of age may also have occurred for the males. The greater sensitivity of the females appears to be associated with the longer duration of their wave and also their slower body growth, but further results are required to confirm these relationships. However, the male animals showed a significant positive regression within the treatments ($P < 0·01$) between body-weight and the stage of cycle at 30 days and between this body-weight and hair-weight ($P < 0·001$). Analyses of covariance using these regressions did not alter the significance of the difference shown for males in Table 1. This suggested that the methoxamine was not acting through effects on growth of the body. The age at which hair growth appeared on the head was not analysed as four of the treated females and one treated and one control male had shown no growth in this position by the end of the experiment. Of those treated animals showing growth in this position, five shed the new growth on the previously clipped area, while seven shed the first-cycle hairs on the head and face as well. This shedding of first- and second-cycle hairs occurred in a definite symmetrical pattern which extended from a line between the ears to a point between the eyes and in some cases extended down the side of the nose. This pattern shedding on the head could also be induced by one 0·35 mgm. dose of methoxamine at the time of commencement of hair growth on the head. Some slight shedding also occurred in a few treated mice on various parts of the body but more detailed studies are required to determine to what extent the reduction in hair-weight is the result of such slight shedding and whether it occurs in those mice where thinning of the coat was not observed.

These preliminary experiments indicate that the control of blood supply can be of considerable importance to the progress of the hair wave and the growth of hair in these mice. The greater sensitivity of the hair follicles of the face and head would suggest that blood supply is more critical in this region. This is probably associated with a lesser supply than other regions during the resting phase of the cycle. The pattern of shedding in the head region was very similar to the pattern of dark fur on the head of the Siamese cat, in which the darker fur is associated with a lower skin temperature and presumably lesser blood supply.

Further experiments are being carried out with vasodilator substances, and, in addition, the various relationships between body growth, the hair wave and the weight of hair grown are being examined for larger numbers of mice. The investigations will be confined to the second hair-cycle, as later cycles have overlapping hair waves, thus making it difficult to obtain the weight of hair grown in one cycle only.

I should like to acknowledge the assistance of Burroughs Wellcome (N.Z.), Ltd., and the Wellcome Foundation in supplying 'Vasoxine' brand methoxamine hydrochloride. The mice are maintained with the assistance of a grant from the New Zealand Department of Scientific and Industrial Research.

F. COCKREM

Sheep Husbandry Department,
Massey Agricultural College,
University of New Zealand,
Palmerston North,
New Zealand.
Nov. 27.

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Glycosidases in Some Farm Animals

IT has been shown that the rat epididymis is the richest known source of α-mannosidase, β-galactosidase and β-*N*-acetylglucosaminidase[1], whereas the female rat preputial gland is the richest source of β-glucuronidase[2,3]. The possibility that the corresponding tissues in large farm animals might be convenient sources of these enzymes was considered. Unfortunately, the ewe, cow and sow lack any gland resembling the female rat preputial gland. The distribution of the four simple glycosidases in ram, bull and boar epididymis is shown in Table 1. For pur-

Table 1. GLYCOSIDASE ACTIVITIES IN TESTIS AND EPIDIDYMIS OF VARIOUS SPECIES

Hyaluronidase results expressed in International Units per gm. (commercial secondary standard employed). Other results expressed as μgm. *o*-nitrophenol (β-galactosidase), *p*-nitrophenol (α-mannosidase and β-*N*-acetylglucosaminidase) or phenolphthalein (β-glucuronidase) liberated per gm. moist tissue in 1 hr. at 37° from the appropriate glycoside.

	Ram		Bull		Boar		Rat*	
	Testis	Epididymis	Testis	Epididymis	Testis	Epididymis	Testis	Epididymis
α-Mannosidase	2,600	5,000	2,700	3,800	3,900	15,000	600	75,000
β-Galactosidase	980	4,800	3,800	3,800	3,200	3,900	2,000	47,000
β-*N*-Acetylglucosaminidase	30,000	118,000	39,000	182,000	48,000	2,000,000	18,000	291,000
β-Glucuronidase	960	1,600	1,800	6,700	38	20	400	5,300
Hyaluronidase	1,400	5,100	550	320	250	890	—	—

* Quoted from Conchie *et al.* (ref. 1).

poses of comparison, the activities in testis were determined, and earlier rat figures are also quoted. The same assay methods as before were employed[1]. Because of the well-known association of β-*N*-acetylglucosaminidase with hyaluronidase in the testis, parallel measurements of the latter enzyme were carried out turbidimetrically[4].

Considering the four simple glycosidases, the most striking feature is the enormously high activity of β-*N*-acetylglucosaminidase in boar epididymis, making this a most convenient source of the enzyme (total weight of tissue from one animal 200 gm.). Very high figures for this enzyme have been recorded in boar semen and epididymal secretion[5]. The figures for β-glucuronidase in boar testis and epididymis are in accord with the statement of Sarkar and Sumner[6] that liver, kidney and spleen are remarkably low in this enzyme in the pig compared with other mammalian species; their method of assay, however, precluded comparison with the results of other workers. Our own figures for pig liver, kidney and spleen were 170, 20 and 110 phenolphthalein units per gm., respectively, which are indeed low for these organs; the non-ionic surface-active agent 'Triton *X*-100' did not increase these figures[7]. So far as α-mannosidase, β-galactosidase and β-*N*-acetylglucosaminidase are concerned, it was found that the activities in these pig tissues were of the same order as corresponding values in the rat[1].

In infant bull and boar testis and epididymis, the general relationship observed for all four simple glycosidases in the rat[1] appeared to hold; whereas the testis figures were equal to, or greater than, the adult ones, the epididymal figures were very much lower.

It can be seen that, in general, the epididymis is at least comparable to the testis as a source of hyaluronidase, but the figure for boar epididymis does not reflect the β-*N*-acetylglucosaminidase value of this tissue.

One of us (J. F.) is in receipt of a grant from the Medical Research Council.

J. CONCHIE
JUNE FINDLAY
G. A. LEVVY

Rowett Research Institute,
Bucksburn,
Aberdeenshire.
Dec. 19.

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Distribution of Kappa-Casein in Skim Milk

RECENTLY, it has been reported that, by differential centrifugation of skim milk, one may obtain casein fractions which differ in their stability toward calcium but which appear identical by electrophoretic analyses[1]. Since the casein micelles are stabilized by kappa-casein[2] and this component is not readily detected by electrophoretic analysis, it appeared that a probable explanation for the above observations is that kappa-casein is not evenly distributed in the micelles of varying size. It is the purpose of this communication to report experimental verification of this hypothesis.

By differential centrifugation of raw skim milk in a fixed-angle rotor, six fractions were obtained containing from 10 to 90 per cent of the total casein. Each fraction was purified by careful solubilization, precipitation at *p*H 4·6, filtration, and thorough washing with distilled water. Casein from the original skim milk was recovered in a similar manner. Electrophoretic analyses revealed no significant differences between the original casein and any of the subfractions.

The whole casein and the six casein fractions, obtained by centrifuging, were hydrolysed with dilute sulphuric acid[3] after which the concentration of N-acetylneuraminic acid was determined by the colorimetric procedure of Svennerholm[4]. The analyses demonstrated a linear increase in the concentration of N-acetylneuraminic acid as progressively more casein was centrifuged from the milk. However, the sample containing 90 per cent of the casein failed to account for 90 per cent of the N-acetylneuraminic acid found in the isoelectric precipitate from the original milk. Therefore, in a second experiment, 86 per cent of the casein was removed by centrifugation and the supernatant liquid was examined. After the casein in this solution had been precipitated and thoroughly washed, analysis for N-acetylneuraminic acid revealed a concentration that was more than twice as great as that found in whole casein recovered from the same lot of skim milk.

A plot of mgm. of N-acetylneuraminic acid per gm. of casein versus per cent casein centrifuged, fitted by the method of least squares, yielded the following relationship:

$$\text{mgm. N-acetylneuraminic acid/gm. casein} = 2{\cdot}61 + 0{\cdot}0156 \times (\text{per cent casein centrifuged})$$

Since about 8 per cent of the casein is non-centrifugable, the above expression was used to calculate the concentration of N-acetylneuraminic acid for each increment of 8·33 per cent of the casein. Based on the results of Waugh[5], Nitschmann[6], and Wake[7], it was calculated that 28·7 mgm. of the acid should corre-

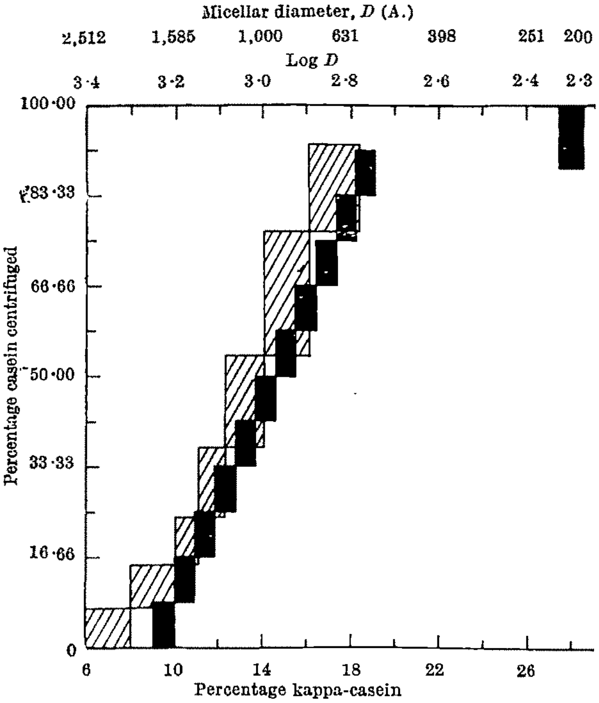

Fig. 1. The size of the casein micelles (shaded blocks) and their content of kappa-casein (solid blocks) as a function of percentage casein centrifuged from skim milk

spond to 1 gm. of kappa-casein. This would account for 15 per cent kappa-casein in whole casein, and the analyses of two samples of whole casein yielded a value of 16 per cent using this factor. The kappa-casein concentrations, calculated in this manner, are shown in Fig. 1 for eleven increments of centrifugation. Although the composition of the soluble casein was obtained from an experiment in which only 86 per cent of the total casein had been centrifuged instead of 92 per cent, it appears that this fraction represents a distinct break from the trend observed with micelles of varying size. The analysis indicates that the non-centrifugable casein may contain as much as 28 per cent kappa-casein.

Since kappa-casein is the component responsible for the stabilization of the casein micelles, perhaps it is not surprising to find a correlation between the concentration of this component and the particle-size distribution of the casein micelles. While the change in concentration of kappa-casein with each increment of casein that is centrifuged demonstrates this relationship, a more direct comparison may be made making use of some unpublished results from this laboratory on the particle-size distribution of the casein micelles. These results were also obtained by differential centrifugation of skim milk in a fixed-angle rotor. The diameters of the micelles were calculated assuming a difference in density of 0·084 between the micelles and serum. The results were corrected for the accumulation of small particles, based on the analysis of gravitational sedimentation[8]. Because of wall effects and possible convection in the fixed-angle rotor, the final analysis must be considered as only an approximate representation of the particle-size distribution. In preparing the frequency distribution curve, it was noted that this became very nearly symmetrical if plotted against the logarithm of the diameter. Therefore, in Fig. 1, a logarithmic scale has been used for the abscissa. The correlation with the results on kappa-casein is quite satisfactory. A detailed description of this work will be published in the near future.

Royal A. Sullivan
Margaret M. Fitzpatrick*
Elizabeth K. Stanton†
Research and Development Division,
National Dairy Products Corporation,
Oakdale, Long Island, New York.
Dec. 12.

* Present address: New York Medical College.

† Present address: Brookhaven National Laboratory.

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Effect of Amniotic Fluid on Inhibition of Growth by Cortisone in Chicken Embryos

The fact that cortisone has an inhibitory effect on growth of chicken embryos was first noted in 1947[1]. A detailed study of this phenomenon was afterwards undertaken by Karnofsky, Ridgway and Patterson[2] and their observations were confirmed by Yamada[3] and by Siegel, Smith and Gerstl[4]. Cavallero, di Marco, Fuoco and Sala[5] secured evidence indicating that the growth-inhibiting effect of cortisone is brought about by an interference with protein synthesis, and an excess of hydroxyproline found by Roberts, Karnofsky and Frankel[6] after cortisone treatment presumably points to the same conclusion. In experiments with weanling rats, Tuchmann-Duplessis and Mercier-Parot[7] failed to counteract the growth-inhibitory action of cortisone by concurrent treatment with somatotropic pituitary hormone, glucosamine or the polysaccharide fraction of human placenta. In chicken embryos, on the other hand, Sobel[8] observed that the deleterious effects of cortisone on growth and survival were partially counteracted by simultaneous administration of somatotropic pituitary hormone.

Montgomery[9] found in baby chicks that the growth-retarding effects of cortisone could be reversed to some extent by injecting beef amniotic fluid in addition to cortisone. A similarly favourable result was obtained by de Franciscis and Magri[10] in young rats treated with cortisone which received simultaneously human amniotic fluid. Subsequent studies by de Franciscis, Magri and Verdoliva[11] established that the cortisone-counteracting properties of the amniotic fluid were bound to protein. We have now made tests to determine if amniotic fluid also has a favourable effect if given subsequent to treatment of chicken embryos with cortisone.

We used in our tests the eggs of White Leghorn fowl and, for treatment, cortisone acetate (Merck) and beef amniotic fluid. The test fluids were injected into the yolk sac after 8 days of incubation. 1·73 mgm./egg cortisone acetate (0·07 c.c. of a 25 mgm./c.c. solution) and 0·15 c.c. amniotic fluid were used. All eggs were opened, and the living embryos were weighed after 18 days of incubation. In a preliminary test we could confirm the growth-retarding effect of cortisone. The weight of 59 control embryos was 20·34 ± 0·37 gm., that of 59 cortisone-treated embryos was 15·43 ± 0·33 gm., with a highly significant difference of 4·91 ± 0·52 gm. between the two groups. Amniotic fluid alone, on the other hand, had no effect whatever on body-weight, the mean weight of the 59 control embryos being 20·34 ± 0·37 gm., whereas that of 84 embryos treated with amniotic fluid amounted to 20·30 ± 0·36 gm. The effect of amniotic fluid on inhibition of growth by cortisone was tested in two experiments. Since there was no significant difference in the results of these tests, the results were pooled. The mean weight of 41 cortisone-treated embryos was 14·02 ± 0·63 gm.; for 63 embryos treated with both cortisone and amniotic fluid the mean weight was 16·18 ± 0·46 gm. The difference amounted to 2·16 ± 0·78 gm. and was highly significant. It is important to note that there was no significant difference between the two groups in post-treatment mortality or in the incidence of gross malformations. As in the earlier tests with rats, it can therefore be concluded that in developing chicken embryos amniotic fluid reduces in a limited, but significant, manner the cortisone-induced retardation of growth. It remains to be determined whether the beneficial effect of amniotic fluid and the similar but more significant one of pituitary growth hormone on retardation of growth following treatment with cortisone is mediated via the endocrine system or, perhaps more likely, is due to an unspecific stimulation of growth.

P. DE FRANCISCIS*
W. LANDAUER

University of Connecticut,
Storrs, Conn. Dec. 15.

* Fellow of the Italian National Research Council.

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Effect of Streptomycin on the Incorporation of Amino-Acids labelled with Carbon-14 into Ribonucleic Acid and Protein in a Cell-free System of a *Mycobacterium*

DURING investigations on the effect of streptomycin on the protein synthesis in *Mycobacteria*, it was observed that streptomycin inhibited the incorporation of ^{14}C-DL-tyrosine into the protein of resting cells of a streptomycin-sensitive strain of *Mycobacterium friburgensis* while it had no such effect on the resistant strain (Table 1).

As phosphorus-32 is incorporated into ribonucleic acid at the same rate in presence and in absence of streptomycin, the site of inhibition is most probably in the synthesis of protein itself. This possibility was tested in a cell-free system.

Table 1. INCORPORATION OF ^{14}C-DL-TYROSINE INTO PROTEINS OF THE INTACT CELLS OF *Mycobacterium friburgensis*
In each tube, 200 mgm. wet weight washed cells suspended in 1·5 ml. asparagin-free Sauton medium were incubated for 30 min. at 37° in a total volume of 2 ml. with 2 μc. ^{14}C-DL-tyrosine, with or without the addition of 100 μgm. dihydrostreptomycin

No.	Strain	c.p.m./mgm. protein	
		Without streptomycin	In presence of streptomycin
1	Streptomycin-sensitive	1,310	735
2	,, ,,	750	406
3	,, ,,	1,135	535
4	Streptomycin-resistant	535	730
5	,, ,,	153	217
6	,, ,,	735	750

Hoagland *et al.*[1] have shown in a cell-free system from rat liver that amino-acids are first bound by a soluble ribonucleic acid and are afterwards transferred to microsomal protein. F. Gros (personal communication) found that the soluble ribonucleic acid in a cell-free system isolated from *E. coli* incorporated amino-acids.

Preparation of a cell-free system of *M. friburgensis* was carried out by Gros's method (private communication), with minor modifications.

The extract of disrupted bacteria was centrifuged at 105,000*g* for 60 min. To the supernatant, 0·5 *M* acetic acid was added to bring the *p*H to 4·5. The resulting precipitate was redissolved in a buffered medium[2]. This preparation was incubated at 37° C. in the presence of ^{14}C-DL-tyrosine and adenosine triphosphate, with and without the addition of streptomycin. Both the protein and the ribonucleic acid were isolated and their radioactivity determined, according to the methods described by Hoagland *et al.*[1].

The results of an experiment with cell-free systems obtained from streptomycin-sensitive and -resistant strains are shown in Fig. 1.

The extent of incorporation of tyrosine labelled with carbon-14 into ribonucleic acid was markedly stimulated in both cases by the addition of streptomycin. On the other hand, streptomycin inhibited labelling of protein in the cell-free system from the

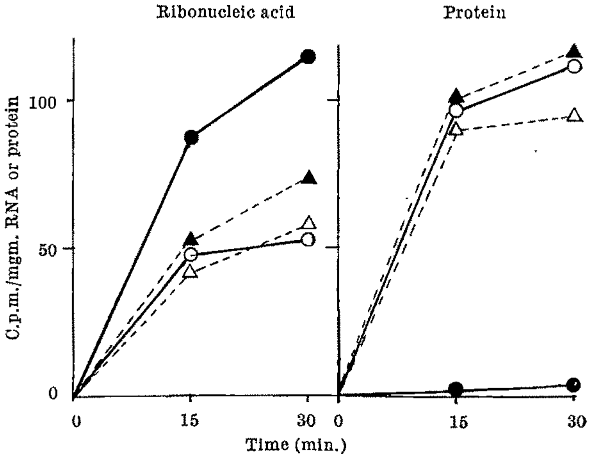

Fig. 1. Labelling of ribonucleic acid and protein with ^{14}C-DL-tyrosine in a cell-free system of streptomycin-sensitive and -resistant strains of *Mycobacterium friburgensis*. In each tube 0·5 ml. of the *p*H 4·5 precipitate (prepared from 1 gm. wet weight cells) dissolved in 1 ml. buffer (ref. 2) was incubated for 15 and 30 min. at 37° in a total volume of 2 ml. with 3 μc. ^{14}C-DL-tyrosine, in presence of 0·01 *M* adenosine triphosphate, with or without the addition of 200 μgm. dihydrostreptomycin. ○, Sensitive strain; ●, sensitive strain in presence of streptomycin; △, resistant strain; ▲, resistant strain in presence of streptomycin

sensitive strain, but did not affect the extent of labelling of protein in the cell-free system of the resistant strain.

This finding points to the specific nature of the inhibition even though the labelled protein fraction is hitherto not characterized. The present results suggest that streptomycin inhibits the transfer of amino-acids from ribonucleic acid to protein.

T. Erdős
Korányi National Tuberculosis Institute,
Agnes Ullmann
Institute of Medical Chemistry,
University, Budapest. Dec. 28.

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PLANT PHYSIOLOGY

Non-respiratory Gas released from Seeds during Moistening

Several investigators have observed that many species of seeds seem to have a relatively high respiratory quotient (R.Q.) soon after they begin to take up water and that the R.Q. decreases and finally levels off with increasing time of imbibition. Stiles and Leach[1] consider such R.Q. variations indicative of shifting metabolic pathways within the seed. Crocker and Barton[2] emphasized that gaseous exchanges of intact seeds do not necessarily reflect actual metabolism. James[3] suggested that these variations in observed R.Q. might be explained by irregularities in oxygen absorption. Our results show that gas, presumably air adsorbed within the seeds, is given off as the tissues become wet. This physical effect may provide another explanation for the shifting values of the apparent R.Q. during imbibition.

Seeds or other materials were placed in the main compartment of a Warburg flask (~ 20 ml. vol.) with 1·0 ml. distilled water, previously boiled to expel dissolved gases, in the side-arm. Flasks were attached to manometers and allowed to stand for equilibration for 15 min. before being closed. After at least 10 min. more, the water from the side-arm was tipped on to the seeds in the main compartment. Gaseous exchange was determined with the Warburg constant-volume respirometer as described by Umbreit *et al.*[4].

Fig. 1 (curves *A*, *B* and *C*) illustrate gas output of Grand Rapids lettuce seed immediately after wetting. That this is not an artefact produced by the tipping process is shown by the steady behaviour with 0·1 ml. of glass beads similarly treated (curve *D*). The seeds in contact with a water-saturated atmosphere for 60 min. (curve *B*) or 120 (curve *C*) min. seemed to produce some gas before the water was tipped from the side-arm. The total net gas produced (curves *A*, *B*, *C*) before and after tipping seemed to be constant, suggesting that the release of gas is a physical phenomenon. Within the limits of experimental error, the results were the same with 0·2 ml. of 20 per cent potassium hydroxide as with 0·2 ml. of distilled water in the centre well, indicating that little or no carbon dioxide was produced. The volume of gas released was calculated from the pressure changes with the assumption that the gas had the water-solubility characteristics of air. This assumption would lead to errors of less than 1 per cent in calculated gas volumes if the gas contained nitrogen, oxygen, hydrogen, carbon monoxide, or nitric oxide in any combinations or proportions. This phenomenon appears to be essentially completed several minutes after the wetting (Fig. 1). Respiratory gas exchange during these few minutes is probably negligible, since we have found $Q_{O_2} \approx 1$ µl./min./100 seeds at 37° C. for fully imbibed (4½ hr.) seeds. The amount of gas released from Grand Rapids lettuce seeds after wetting increased with increasing temperature (Table 1).

Table 1. Gas produced within 10 min. after wetting Grand Rapids Lettuce Seeds at Different Temperatures

Temperature (° C.)	µl. Gas (S.T.P.) per 100 seeds
7	11
17	25
27	87
37	157

Table 2. Gas produced from Various Materials within 10 min. after Wetting

Material	Temperature (° C.)	Gas produced (µl./100 mgm.)
Buckwheat seeds*	16	45
Rape seeds*	16	49
Tomato seeds*	16	83
Tobacco seeds*	16	73
Lettuce seeds*	23	113
De-coated lettuce seeds*	23	104
Lettuce pericarp ('seed coats')	22	139
Killed lettuce seeds†	23	169
Killed lettuce seeds‡	23	182
Dry, green tea leaves	23	144
Powdered potato starch	23	183

* Viable.
† Rendered non-viable by heating at 95° C. for 12 days.
‡ Killed (after 3-hr. imbibition) by freezing then heating to 95° C. for 10 days.

Similar experiments with different materials are reported in Table 2. Non-viables seed, which neither germinated nor respired, showed the effect, as did dried tea leaves and potato starch. Therefore the phenomenon observed with viable seeds seems to be a general property of dry plant material.

The gaseous output observed when dried material was moistened cannot be explained by simple displacement of air at atmospheric pressure, since in this case the total pressure of the system would remain unchanged. Thus the gas was either trapped under pressure or it was adsorbed upon surfaces within the material. Because of the variation of output with temperature (Table 1) and also because the volume of gas released at 37° C. was approximately twice the total volume of the dry seeds, we favour the explanation in terms of colloidal adsorption[5].

The pertinence of this physical phenomenon to the experimental determination of R.Q. values is obvious. Non-respiratory evolution of gas as described here would lead to calculation of mistakenly high R.Q. values. Fig. 1 suggests that this non-respiratory phenomenon can occur over a period of several hours when seeds are moistened slowly. To illustrate our argument, we note that peas have been reported to

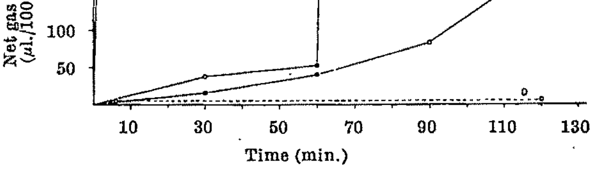

Fig. 1. Gas released from lettuce seeds at 37° C. Seeds were kept in a water-saturated atmosphere until moistened at times indicated

have the exceptionally high R.Q. of 6·0 after a 4-hr. soaking, with a decrease to 1·8 after 8 hr., and a further decrease with increasing time[2,3]. Allerup[6] showed, however, that it takes approximately 18 hr. for peas to complete their imbibition of water. Thus it may be suggested that non-respiratory gaseous output during wetting accounted for the high apparent R.Q. values reported after 4 and 8 hr.

These experiments suggest certain precautions for studies of respiration of intact seeds and similar biological material. Examination of the literature suggested that this unrecognized non-respiratory gas output in many instances led to mistakenly high apparent R.Q. values before water imbibition had been completed.

ALAN H. HABER
NANCY BRASSINGTON*

Biology Division,
Oak Ridge National Laboratory†,
Oak Ridge, Tennessee.

* Biology student trainee from Winthrop College, Rock Hill, South Carolina.

† Operated by Union Carbide Corporation for the United States Atomic Energy Commission.

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A Two-Stage Fermentation of Cassava

ONE of the staple foods of the people of the rain forest belt of West Africa is gari, a starchy food prepared from the root of the cassava plant (*Manihot utilissima*). The traditional preparation of gari[1] consists briefly of the following stages: both the corky outer peal and the thick cortex are removed; the body of the root is grated by hand on home-made raspers; the greater part of the juice is removed from the pulp by primitive pressing; the pulp is left in bags for 72–96 hr. before it is fried. During this time fermentation occurs; hand-made raffia fabrics are used for 'sifting'. A certain amount of fibre and ungrated ends of the roots are removed here. The pulp is afterwards heated in large iron pans over an open fire with or without the addition of palm oil.

We have recently been investigating the microbiology of the traditional preparation to determine the conditions needed for mechanized production of this foodstuff in Nigeria.

It is well known that the cassava root contains a cyanogenic glucoside which renders it poisonous if eaten fresh, and that during the traditional methods there is a holding stage during which this glucoside decomposes with liberation of gaseous hydrocyanic acid and after which the material is safe to eat.

The presence of hydrocyanic acid in cassava roots was first recorded by Boutron Chalard in 1836 [2]; but it was found that the acid is not present in cassava roots in its free state but in the form of a glucoside[3]. This was later found to be identical with the glucoside present in the beans of *Phaseolus lunatus*, phaseolunatin[4]. The precise nature of the process by which the glucoside is broken down, and what, if any, other changes occur during the holding stage, which lasts three or four days, is not clearly stated. It has been suggested that the glucoside is hydrolysed by the same mixture of enzymes as is present in the beans of *Phaseolus lunatus*[4]. In a more recent publication[5] Oyenuga and Amazigo refer to the glucoside as "linamarin" and to the enzyme responsible for its hydrolysis as "linase".

We have succeeded in preparing partially purified cyanogenic glucoside from the pressed juice of cassava roots, using the cortex and the inner flesh, from which the starch and other suspended matter were removed by centrifuging followed by filter pressing. This juice was found to contain 0·0045 per cent hydrocyanic acid, that is, its glucoside content is of the same order as that of the cortex of bitter cassava. The material was free from protein and may therefore be regarded as uncontaminated with any plant enzyme. This material is very unstable and undergoes spontaneous hydrolysis at *p*H's less than 7. During its isolation the glucoside was stabilized with potassium hydroxide and the sugars were removed with Fehling's solution until all reactions for sugars were negative. The compound was then purified by crystallization from alcohol. The purified glucoside hydrolysed spontaneously after acidification, liberating hydrocyanic acid and glucose.

Further, we have consistently isolated two organisms from grated cassava during the holding stage of the traditional preparation of gari: (*a*) A member of the genus *Corynebacterium* characterized by the production of yellow colonies on nutrient agar, and the fermentation of starch with the production of acid only. This organism does not appear to be recognized in Bergey's "Manual of Determinative Bacteriology", and the specific name of *Corynebacterium manihot* is suggested for it. (*b*) The fungus *Geotricum candida*.

The *Corynebacterium* was found in increasing numbers during the first 48 hr. of the fermentation, and was then replaced by the *Geotricum*, which by the third or fourth day was the predominant organism.

We therefore suggest that the process of detoxification of cassava root that occurs in the preparation of gari should be regarded as a two-stage fermentation. In the first stage the *Corynebacterium* attacks the starch of the root with the production of various organic acids, and the lowering of the *p*H causes spontaneous hydrolysis of the cyanogenic glucoside with liberation of gaseous hydrocyanic acid. When sufficient organic acids, including lactic acid, have been produced, conditions become favourable for the growth of the *Geotricum*, and this then proliferates, producing a variety of aldehydes and esters. These last products appear to be responsible for the characteristic taste and aroma of the gari.

Acting on the two-stage fermentation hypothesis, we have prepared gari in 24-hr. using as starters a mixture of pure cultures of the two organisms mentioned above, and this product has been tested by feeding it to volunteers. They were unable to tell the difference between the gari produced in 24 hr. by the use of the pure culture starter and the traditional product produced by 4 days holding. We have also found it possible to shorten the fermentation to 24 hr. by using as a starter pressing water from the first stage in the preparation of the roots which had been kept at room temperature for 4 days, and which, on examination, was found to contain enormous numbers of both the *Corynebacterium* and the *Geotricum*. A description of this starter technique has been published in a report on improved methods of preparing gari circulated by the Federal Ministry of Commerce and Industry, and the method is being adopted by some co-operative societies.

Further work on the chemistry of the cyanogenic glucoside is in progress and will be published elsewhere. A full account of the new species of *Corynebacterium* is in preparation and will be submitted for publication elsewhere.

We wish to thank Mr. K. R. Butlin, National Chemical Laboratory, Teddington, for kindly checking the characteristics of the two organisms.

PATRICK COLLARD
Department of Bacteriology,
University College,
Ibadan.

SIMON LEVI
Federal Institute of Industrial Research,
Ministry of Commerce and Industry,
Lagos. Dec. 23.

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AGRICULTURAL SCIENCE

Spraying of Barley with 2,4-Dichlorophenoxyacetic Acid

DR. H. INGVARD PETERSEN has discovered differences in the translocation of the plant growth regulator herbicides applied to cereal plants of different ages[1]. His autoradiographs show that whereas radioactive 2,4-dichlorophenoxyacetic acid applied to barley at the one- to three-leaf stage is readily translocated to all parts of the plant, including, presumably, the growing point, application to successively older plants results in progressively less translocation. This plant growth regulator herbicide applied to the fifth and sixth leaves of a five- to six-leaf plant appears to be translocated to a very limited extent indeed.

I note with interest Dr. Petersen's conclusion that this may account for the fact that cereals do not develop deformed heads after treatment with 2,4-dichlorophenoxyacetic acid at the five- to six-leaf stage, whereas treatment at earlier stages leads to interference with the pattern of differentiation of the spikelet primordia and deformed heads. Hitherto it had been thought that the leaf and spikelet primordia are sensitive to damage by the plant growth regulator herbicides when first initiated but become progressively resistant as their development proceeds. In view of Dr. Petersen's alternative explanation, it is worth while to examine more closely the evidence for this latter concept.

Fig. 1 shows photomicrographs of the growing point and developing spike of barley sprayed with 2,4-dichlorophenoxyacetic acid at a series of stages between one and six leaves. The apices were dissected and photographed some days after treatment.

Plant 1 was sprayed when the ultimate leaf initial was appearing, that is, just before transition to the reproductive stage. The plant had one expanded leaf and the second was emerging. The small arrow points to the developing leaf primordium which can be seen to be a 'ring' of tissue completely encircling the stem. This is the aberrant type of cell differentiation which gives rise to the 'tubular leaf' abnormality. (Normally, growth of a leaf primordium is restricted to one side of the stem and the leaf margins are free, not fused as in the 'tubular leaf'.)

Plant 2 was sprayed when transition to the reproductive phase had just taken place and the lower spikelet primordia were in the early phase of development, characteristically the 'double ridge' stage, but were not organized further. As may be seen, these lower primordia are grossly aberrant (arrow). They would give rise to the 'opposite spikelets' or 'whorled spikelets' abnormality or may be abortive. It should be noticed, however, that the ultimate leaf is apparently developing quite normally and from experience it is known that it will give rise to a normal leaf. It is suggested that by the time of the treatment it had already developed to a stage when it was no longer susceptible to damage by the synthetic growth regulator.

Plant 3 shows the effect of spraying when subsequent spikelet primordia were at the very early phase of development but when the lower, first formed, spikelet primordia had progressed somewhat. Clearly, the subsequent spikelet primordia are severely affected (arrow) but the lower ones are developing quite normally. It is suggested that these lower spikelets had progressed beyond the sensitive phase when the growth regulator was applied. Lack of translocation can scarcely account for the lack of

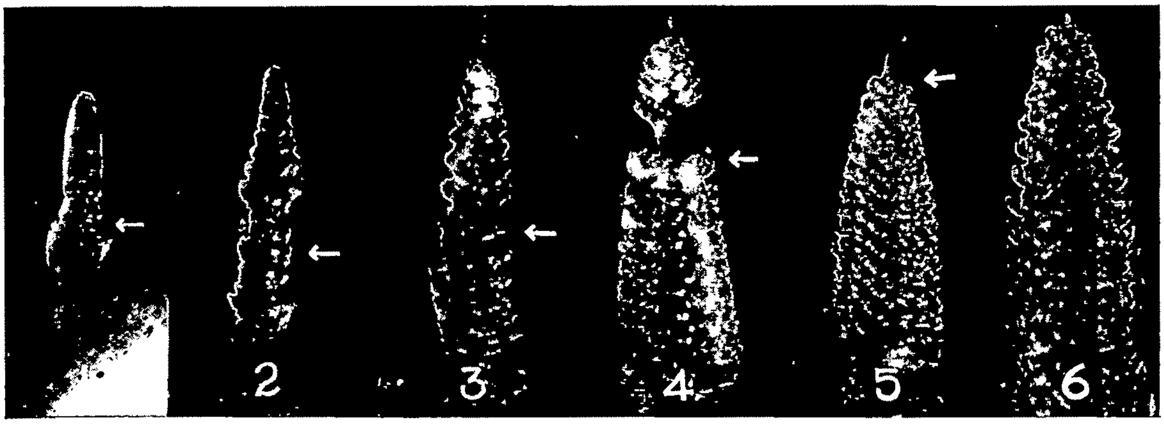

Fig. 1. Photomicrographs of the growing point and developing spike of barley plants sprayed with the equivalent of 0·5 lb. per acre of 2,4-dichlorophenoxyacetic acid. Plant 1 was sprayed when the growing point was vegetative and had the second leaf just visible. Plants 2, 3, 4, 5 and 6 were sprayed at a succession of stages during the reproductive phase. The most advanced, plant 6, had five to six leaves when sprayed

effect on these lower spikelets since those developing higher on the rachis were affected.

Plant 4, which was sprayed at a later stage, demonstrates this point still further, and plant 5 shows the effect of spraying when only the last few spikelet primordia remained to be initiated before the growing point ceased to grow.

Plant 6 was sprayed when all the spikelet primordia were laid down and had progressed beyond the early phase of their initiation.

In every case the spikelet primordia below the point of abnormality have developed quite normally, and it is known that in practice they produce normal fertile flowers and seed. Thus it appears to me that, while Dr. Petersen's work may show translocation to be a contributory factor in the increasing resistance of barley with age to damage by the plant growth regulator herbicides, the age (or more correctly the stage of development) of the leaf or spikelet primordia must still be regarded as a major factor governing susceptibility to damage.

A great deal of work has been carried out here on the effect of the plant growth regulator herbicides on cereals and it has been found that the situation is highly complex. We have found considerable variation to occur in the behaviour of different growth regulators. For example, in barley, α(2 : 4-dichloro-3-methylphenoxy)propionic acid and α(2 : 4 : 5-trichlorophenoxy)propionic acid both cause spikelet abnormality (usually sterility) even when applied at a late stage of primordial development, while others, such as α(4-chloro-2-methylphenoxy)propionic acid, cause relatively little abnormality even when applied at the most sensitive stage. Work is in progress, using carbon-14 labelled growth regulators, to attempt to resolve the causes of these differences. I am indebted to Dr. Petersen for bringing to my notice the important part that translocation may play.

E. L. LEAFE

Research Department,
Agricultural and Horticultural Division,
Boots Pure Drug Co., Ltd.,
Lenton Experimental Station,
Nottingham. Jan. 6.

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'Karathane' : the Value of its Differential Fungicidal Effect in Relation to Mildew and Yellow Rust of Wheat

EXPERIMENTAL work with yellow rust (*Puccinia glumarum* (Schm.) Erikss. and Henn.) on wheat seedlings under glasshouse conditions has been considerably hampered by epidemics of cereal mildew (*Erysiphe graminis* D.C.). Control of these epidemics has proved difficult because environmental conditions in a normal glasshouse cannot be kept within narrow limits and because fungicides which have been effective against the mildew have also been toxic to the rust. Reports of the effectiveness of 'Karathane' (2 : 4-dinitro-6-(1-methyl heptyl) phenyl crotonate) when used either as a wettable powder or as a fumigant for the control of many powdery mildews but no other disease prompted us to examine the possibility of its being of use in this instance.

A number of seedlings bearing uredosori of yellow rust were fumigated with 'Karathane' when the first mildew pustules appeared. Subsequent development of both diseases was compared with that on similar, untreated seedlings. The flush of mildew pustules, which typically follows 4–5 days after the initial infection, occurred on the untreated seedlings but not on those fumigated. Mycelial growth of the mildew was not entirely suppressed but the pustules were thinner and more widespreading than normal. The yellow rust was apparently unaffected and continued to produce uredosori in a typical zonation.

In subsequent experiments it was found that both rust-resistant and rust-susceptible seedlings fumigated with 'Karathane' 1–10 days before and 2–10 days after inoculation with uredospores gave the anticipated host reaction. Furthermore, uredospores taken from plants only 20 hr. after fumigation successfully infected the seedlings to which they were inoculated.

A microscopical examination of both fungi was made 20 hr. after fumigation. The yellow rust uredospores from treated and untreated seedlings were indistinguishable, but some differences were noted in the mildew spores. Oidia were stained with cotton blue in lacto-phenol before examination. Those from treated plants had a granular, unevenly stained cytoplasm and the nuclei were well stained and clearly visible. Some bursting and irregularities of the spore wall was also noted. Oidia from untreated plants were more uniformly and more densely stained and consequently the nucleus was not as clearly visible.

During experiments with seedlings it was found that the mildew could be kept under control without any adverse affects on the yellow rust for a period of at least 8 weeks by regular fumigation with 'Karathane' immediately fresh mildew pustules appeared. Under the conditions prevailing during the experimental period, this was at about 10–12 day intervals.

D. A. DOLING
SHIRLEY HEPPLE*

National Institute of Agricultural Botany,
Cambridge.
Jan. 5.

* Present address: School of Agriculture, University of Cambridge.

BIOLOGY

Œstrous Cycle, Gestation Period and Parturition in the Marsupial *Trichosurus vulpecula*

COLONIES of the brushtailed possum, *Trichosurus vulpecula* Kerr., a marsupial, have been kept in Sydney since May 1954 and in Adelaide since January 1957. Breeding seasons were studied, in both places, in the local wild populations from which the captive animals were derived. Breeding in the Sydney colony began in June 1955 and in the Adelaide colony in March 1957. To date 46 specimens (including 16 second-generation young) have been born in captivity. Only one young is normally reared each year in the wild in the Sydney area, but it seems that many wild females in the Adelaide area rear two young each year.

T. vulpecula is polyœstrous. Daily vaginal smears were taken from 13 females in the Adelaide colony over periods of up to 10 weeks. In these the œstrous cycle varied in length from 21 to 30 days (average 24½ days). Œstrus did not occur in lactating females with young in the pouch, but if the pouch-young were removed such females came into œstrus between 4 and 10 days later. Females which lost pouch-young often produced a second young soon afterwards, although no female in the Adelaide colony conceived at the first œstrus after the cessation of lactation. However, a female in the Sydney colony is presumed to have conceived at this time for it produced two offspring within about one month, the first young having been lost when less than 8 days old. Two captive females are known to have reared two offspring each in one year.

The gestation period in 3 animals in the Sydney colony was between 17 and 21 days. The interval between the appearance of sperms in the daily vaginal smear and parturition was between 16 and 17 days in one Adelaide female and 17–18 days in two others. Since copulation occurred some time prior to smearing, the gestation period is assumed to be about 17½ days. The gestation period of *T. vulpecula*, like that of the American opossum *Didelphis virginiana*[1] and the wallaby *Setonix brachyurus*[2] is thus shorter than the length of one œstrous cycle.

On July 28, 1958, one of us (A. G. L.) witnessed parturition in *T. vulpecula*. The female showed signs of restlessness and thereafter put herself in a sitting position, facing the front of the cage with the hind-limbs partly extended. Fluid exuded from the urogenital opening and an embryo, free of fœtal membranes, was expelled, followed by more fluid. Unfortunately, the embryo fell from its mother through the wire-mesh floor of the cage into a tray of sawdust. The mother then licked the urogenital opening. She was then taken from the cage, held on her back in a horizontal position, and the young recovered from the sawdust, washed with normal saline, and returned to the region of the urogenital opening. The young turned to face the direction of the pouch and crawled through the fur by alternate over-arm movements of the fore-limbs. The posterior margin of the pouch, approximately 7 cm. from the urogenital opening, was reached in 7 min.; the distance would have been less if the mother had been held in a sitting position. The young did not immediately enter the pouch but continued to its anterior margin—a further distance of about 4 cm. It then turned round and crawled back to the posterior margin, where it again turned and proceeded forward several centimetres before entering the pouch. A slight relaxation of the pouch opening was noticed when the young was crawling at the margin. A period of 5 min. elapsed from the time of arrival at the posterior margin to the time of entry into the pouch. After the young had entered it crawled about but was unable to gain either of the two teats, although it tried for a period of approximately 20 min. It was then removed, weighed, photographed and examined before fixation.

Earlier descriptions[3-5] of parturition in marsupials suggested that the female licked a track in the fur from urogenital opening to pouch, up which the young climbed. In this instance the mother neither licked the fur nor assisted the young in any other way. This is in keeping with recent observations on birth in *Didelphis*[1].

The new-born *T. vulpecula* observed was 13 mm. in crown–rump length (measured between 2 parallels) and 6 mm. in head-length. Its weight was 0·20 gm. and its mother's weight 2,030 gm. Another specimen removed from the pouch a few hours after birth (Adelaide colony) was of comparable size and weighed 0·21 gm. In the first specimen the ratio, weight of newborn to weight of mother, was less than 1 : 10,000. Ratios for other mammals vary from 1 : 60,000 for kangaroos to as high as 1 : 3 for some bats[6].

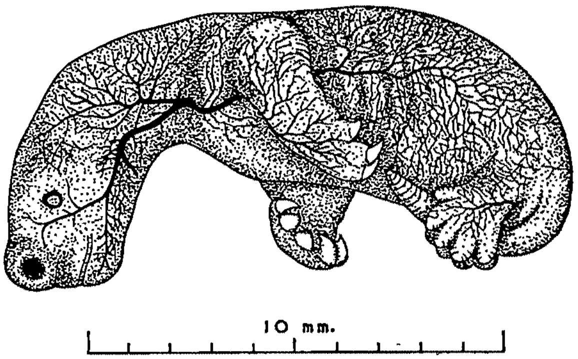

Fig. 1. *Trichosurus vulpecula*. New-born unattached young. Note the conspicuous blood vessels as seen through the integument in the living specimen, and the strongly developed fore-limbs, with claws, which are used for climbing into the pouch

The living new-born was semi-transparent and pinkish in colour with a conspicuous network of blood vessels visible through the skin (Fig. 1). The fore-limbs were strongly developed, and all digits of the manus were equipped with well-developed sharp-pointed claws turned inwards towards the palm. As the fore-limbs alone were used in climbing into the pouch these claws appear to be important structures which aid the young to grip the mother's fur. The new-born young continued to make crawling movements and was observed to flex the digits of the manus, after removal from the pouch. Well-developed claws formed by the epitrichium were observed on the fore-limb digits of *D. virginiana*[6], the native cat *Dasyurus quoll*[7], and the bandicoots *Perameles gunnii* and *Isoodon obesulus*[8], but these were shed soon after birth. Those of *T. vulpecula* are also of epitrichium but are still present 5 weeks after birth and probably persist much longer. It has been suggested[9] that the claws of *T. vulpecula* are not shed during pouch life as are those of other species.

The hind-limbs were not as well developed as the fore-limbs. The plantar surfaces were directed towards the mid-ventral line, and the partly separated digits of the pes were distinct. Claws were not discernible. The oral aperture was oval to circular in shape, the lips being fused to form the characteristic sucking mouth of juvenile pouch-young. The pigmented portion of the eye could be seen through the epitrichium that covered the whole body. The nostrils were well developed, but the folded pinna of the ear could only be discerned with difficulty. Part of the umbilical cord was still attached. It was not possible to sex the new-born as neither pouch nor scrotum was developed.

A. G. Lyne

Division of Animal Health and Production,
Commonwealth Scientific and
Industrial Research Organization
Sheep Biology Laboratory,
Prospect, New South Wales.

Phyllis E. Pilton
G. B. Sharman

Department of Zoology,
University of Adelaide. Dec. 4.

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A Relationship between some Bacteria, Protozoa and Diet in Early Weaned Calves

EARLY weaning of calves on to a solid diet is now becoming more common, and investigation of the establishment of ciliate protozoa in calves reared according to Preston's system[1] indicated that although numerous ciliates might be established by the end of the second week when only milk and roughage were being fed, these disappeared immediately a large proportion of concentrates was included in the diet. Microscopic observations suggested that the numbers of ciliates were inversely related to the numbers of *Lactobacilli*, which were directly related to the proportion of concentrates in the diet. It thus seemed of interest to investigate the influence of diet on the flora and fauna of early weaned calves, as the establishment of an adult rumen population might aid in the digestion of an adult diet. Some preliminary results on two calves fed widely different ratios of hay and concentrates are given here. The organisms selected for cultural study were those which previous results had suggested might be related in numbers.

The calves were inoculated by stomach tube at weekly intervals (from 8 days) with a concentrated suspension of rumen ciliates and associated bacteria, and thereafter samples were taken at weekly intervals for visual assessment of bacteria and protozoa and viable counts of three types of organisms. *Lactobacillus* species were counted by making serial ten-fold dilutions of the rumen contents into a semi-solid tomato–glucose medium[2]. The highest dilutions showing growth of Gram-positive, catalase-negative, non-nitrate-reducing, asporogenous rods were recorded. The other two were a large Gram-negative lactate-utilizing coccus[3], which has been shown to be one of the principal bacteria in the rumens of young calves and to be present only in small numbers in older animals[4], and *Veillonella gazogenes*[5], another lactate-utilizing coccus. Ten-fold dilutions were made in a semi-solid lactate-containing medium[4] and examined for growth after 2 days incubation at 38°.

The two Ayrshire bull calves were kept in similar environments under ordinary conditions and both fed whole milk alone to 7 days and weaned at 21 days. Dried grass was available to calf *A*, but was fed by bucket to calf *B* from 7 days. Concentrates (containing 8 mgm./lb. 'Aurofac 2*A*') were added to the diet of calf *A* from 15 days and the amount was increased to 1,800 gm./day by about 8 weeks. Calf *B* was offered, and completely consumed, a 3 : 1 mixture of the same dried grass and concentrates, which was increased gradually to appetite until by 13 weeks it was eating a total of 2,000 gm. Over a period of 4 days in the sixteenth week the weight of concentrates given to calf *B* was increased to 1,800 gm./day and the grass reduced to zero. Thereafter, the concentrates were kept constant and grass was made available *ad lib.* from the seventeenth week.

The *p*H values of the rumen contents of calf *A* were lower than those of calf *B*, but became more nearly 7 from the thirteenth week as the *Lactobacillus* counts decreased. The results of viable counts are shown in Fig. 1. The number of *V. gazogenes* remained relatively constant at about the adult-level whatever the diet. However, while the numbers of *Lactobacilli* and large cocci were about the same in each calf at the end of the period on milk alone, the subsequent numbers depended very much on the amount of concentrates in the diet, and this also affected the ciliate population. The mixed fauna established in calf *B* remained throughout the experiment, whereas the first appearance of ciliates in calf *A* after weaning was at 12 weeks old, and they reached the level found in *B* by about 17 weeks. The microscopic observations showed a varied bacterial population, other than the main types cultured, to be present in both calves from an early age, and suggested that some small Gram-negative organisms, other than *V. gazogenes*, varied in numbers inversely with the *Lactobacilli*. The rapid changes in diet of calf *B* at 16 weeks, although affecting the cultured bacterial populations, did not affect the protozoa, and direct observation at this time showed few typical *Lactobacilli* such as had previously been associated with a high cultural count. In some concentrate-fed sheep although *Lactobacilli* were cultured in numbers of up to 10^6/ml. rumen contents, few morphologically typical *Lactobacilli* were seen in films of the rumen contents.

These results again suggest that in normal circumstances the rumen flora and fauna are greatly influenced by diet and possibly other, at present unknown, factors, and that rumen inoculations can only be successful provided that the rumen environment is suitable for the development of the added organisms[6,7]. This has also been found to be the case in other animals as inoculations of the large coccus into older calves and sheep have failed to establish them in the rumen. The initial presence of some organisms might also influence the growth of others, and a possible relationship can be noted here between the lactate-producing *Lactobacilli* and the lactate-utilizing large cocci. However, other factors must be concerned in the final balance of the bacterial population, as the numbers of *V. gazogenes*, which might be expected to be more directly influenced by the avail-

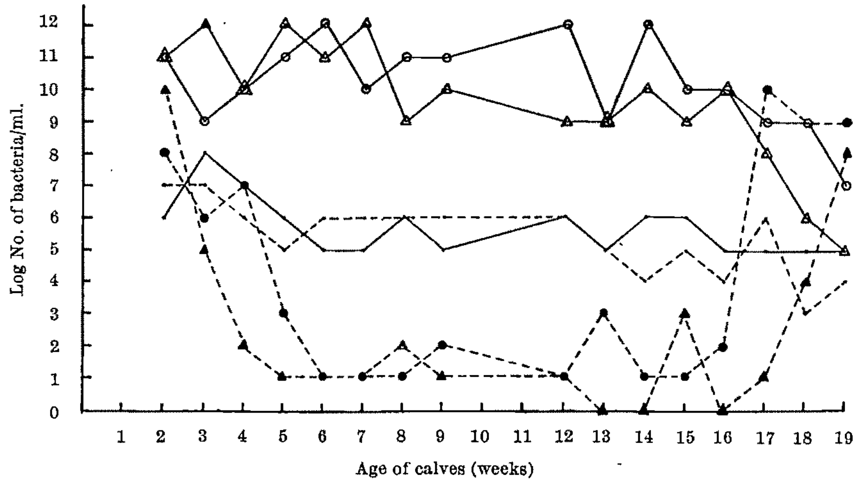

Fig. 1. Viable counts of some rumen bacteria in calves on different rations of hay and concentrates. Calf *A*, *Lactobacilli* –○–, large cocci –△–, *V. gazogenes* –•–. Calf *B*, *Lactobacilli* – – ● – –, large cocci – – ▲ – –, *V. gazogenes* – – • – –

able lactate, show little difference between the two animals.

We wish to thank Dr. T. R. Preston for providing and feeding the calves, and Miss S. Bell and Mr. W. Shand for technical assistance.

J. Margaret Eadie
P. N. Hobson
S. O. Mann

Rowett Research Institute,
Bucksburn, Aberdeenshire. Dec. 11.

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A Photographic Method for recording Activity and Behaviour in a Group of Small Animals

It is often desirable to obtain a quantitative measure of the activity of insects or other small animals over a specific period of time. Recently, an attempt was made[1] to overcome some of the inherent difficulties found when using the familiar mechanical methods for recording the activity of smaller insects. Moreover, Nielsen[2] reported a photographic method, which does not depend upon the mass of the insect, for estimating the number of changed positions in a group of mosquitoes at regular intervals. His method is especially suitable for use in darkness with insects that are affected by ordinary light but which do not respond to an electronic flash.

Nielsen's method has a disadvantage in that each photograph of the insects is compared with its predecessor to give an activity value based upon the number of insects which have changed position in the interval. Each number obtained from such a comparison contains within it an unknown factor, namely, the amount of movement of the insects occurring between the two exposures upon which the number is based. That is, each numerical item in the data contains an inherent unknown. In addition, comparison of adjacent exposures to determine which insects moved during the time-interval is a time-consuming task. It would probably exceed one's endurance to use this method often, for example, with exposures taken at 2-min. intervals over a period of 24 hr. Furthermore, the method is not suitable for use with large numbers of animals. Overlapping changes in positions with time would frequently confuse the interpretation.

During some studies in this laboratory it has been necessary to monitor the amount of movement in a group of adult *Drosophila melanogaster* Meig. over relatively long periods of time. The photographic method used employs a slow shutter speed to determine the number of insects in the group which are not moving when each record is taken. With this method each photographic exposure is autonomous, providing in itself a useful number with no inherent unknown motion factor, without the need for comparing it with its predecessor. It is possible, therefore, to examine a large number of negatives in a relatively short time. In addition, the principle of a slow shutter speed will allow relatively large numbers of animals to be used in the experimental container if desired.

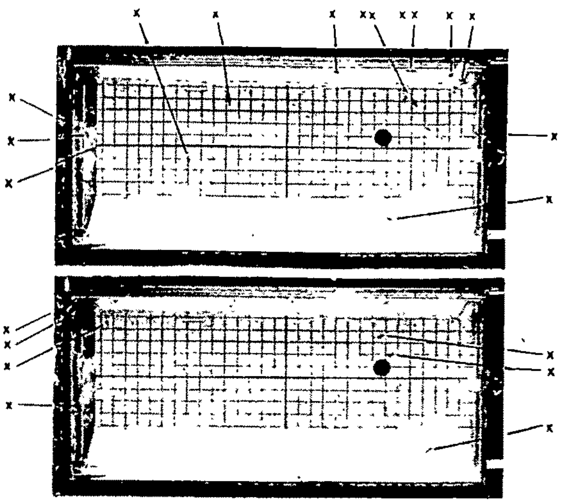

Fig. 1. 1-sec. exposures of box containing 15 insects. *x*, One stationary insect. Top, 14 insects stationary at 1745 hr.; bottom, 7 insects stationary at 2100 hr.

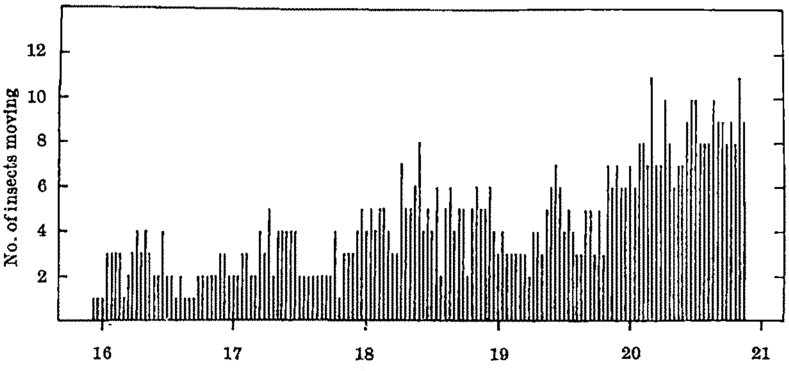

Fig. 2. Number of moving insects at 2-min. intervals over 5 hr., determined for 15 adult *D. melanogaster*, post-emergence age 24 hr., in constant illumination with water only

A plastic box (16 cm. × 7·5 cm. × 4·5 cm.) with a transparent front contains the insects. The box is mounted upright on its longer side. The sides are constructed to slope inward toward the back, thereby affording a ready view of the whole interior through the transparent front. Water, or a 15 per cent sucrose solution, is admitted through a constant-supply tube inserted through the back of the box. The insects, after being taken from the culture medium, are allowed to move along a tube into the box through a small hole at one end, which is afterwards closed. An automatic camera is mounted approximately 2 ft. from the transparent front. A clock is set beside the insect box in the camera field. With the camera diaphragm set at $f/16$ sufficient depth of field is provided for the clock and all parts of the box to be in focus. Illumination is provided by two 15-watt, 17-in. fluorescent tubes above and in front of the camera lens and a reflecting surface in the corresponding position below. Exposures of 1-sec. duration are made. Thus, insects moving during the exposure either will be blurred on the negative or, as is usually the case, will not show at all. A record is therefore obtained of the number of stationary insects during the exposure. Fig. 1 shows two sample photographs. The greater number of visible insects in the first exposure indicates the smaller amount of activity; conversely, fewer visible insects in the second exposure indicates a higher level of activity.

The frequency of exposures is determined by the nature of the experiment. In the present work at least two kinds of series are used. In one, a group of photographs (usually 12–14) is made automatically with 1-min. intervals, every 2 hr. The results from each group are averaged, and the total number of insects minus this mean is plotted against the mean time at which the photographs were taken. In a type of experiment where more rapid activity changes are expected, one exposure is made every 2 min. throughout the test period. The negatives on the long strip of 35 mm. film (25 ft. for 6½ hr.) are examined with a dissecting microscope and the number of stationary insects in each exposure is determined. Fig. 2 indicates increasing, somewhat rhythmic, activity for 15 starved adult *D. melanogaster* over a period of 5 hr. in constant illumination.

This method provides rapid and accessible records of: (1) the number of insects stationary during each exposure; (2) their positions in relation to special items, such as the food supply. Both kinds of results are readily obtained from each exposure as an individual unit without comparing adjacent pairs. Some effects on activity of varying periods of light and dark may possibly be studied with this technique by timing the light source to remain on only during the 1-sec. exposure and by varying the experimental lighting conditions. The method should prove useful in studies with other small animals besides insects. A report of the present studies of insect activity in relation to the local passage of weather systems will be presented later.

D. K. EDWARDS

Forest Biology Laboratory, Federal Building,
Victoria, B.C. Dec. 15.

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Photochemical Reduction of Blue Tetrazolium by Isolated Chloroplasts

THE use of oxidation-reduction colour indicators the solubility of which is unchanged during reduction in the Hill reaction of photosynthesis provides no information as to the site in the chloroplast in which the reaction occurs. Dyar[1] used blue tetrazolium, which is colourless and soluble in the oxidized form in water but insoluble and highly coloured when reduced, to localize regions of dehydrogenase activity in plant cells. In chloroplasts reduction was apparently confined to grana-like bodies. In some materials the reaction was dependent on light, suggesting a relation to the Hill reaction. Since non-plastid cytoplasm may have contributed to the reaction, we were interested in whether isolated chloroplasts were capable of reducing the dye.

Intact chloroplasts were isolated from red kidney beans essentially by Jagendorf and Evans's method[2]. The isolation buffer consisted of 0·3 M sucrose, 0·05 M pH 8·5 phosphate and 0·01 M potassium chloride. 5 gm. of interveinal tissue from primary leaf blades of red kidney beans were ground with 15 ml. buffer for 20 sec. in a Waring blendor, model *PH*-5, in the high-speed position. The homogenate was filtered through cheese-cloth, and the filtrate centrifuged for 3 min. at 1,000g. The resulting pellet, consisting mainly of whole chloroplasts, was made up to the original volume with pH 6·5 $M/10$ phosphate buffer. Equal volumes of the chloroplast suspension and Dyar's blue tetrazolium solution were mixed in Thunberg tubes and, after evacuation, incubated at 32° C. for 1 hr. in a water-bath, either in the dark, or illuminated at 20 cm. from a 100-W. incandescent bulb.

Reduction of the chemical, indicated by the development of a deep blue colour, was confined to grana-like structures, as in the chloroplasts in cells pictured in Dyar's article. The reaction was dependent on light, as was the staining of chloroplasts in intact mesophyll cells when small pieces of leaf were incubated with the blue tetrazolium solution.

Irradiation of chloroplast preparations 5 cm. from an *SL* 2537 'Mineralight' ultra-violet lamp (UV Products, S. Pasadena, Calif.) for 30 min. prevented development of colour.

These results extend Dyar's observations on reduction of blue tetrazolium to isolated chloroplasts, and suggest that the reaction may prove useful as a sensitive test of the structural integrity of chloroplasts during fractionation.

This work was supported in part by U.S. Public Health Service grant *E*-596*C* to one of us (M. C.).

JOHN J. TAYLOR
MEYER CHESSIN

Departments of Bacteriology and Botany,
Montana State University, Missoula. Dec. 16.

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Physiological Races of *Phytophthora infestans* Mont. (de Bary) in Northern Ireland

THE presence of several races of the blight fungus, *Phytophthora infestans*, was recorded in Northern Ireland by Doling[1]. Races commonly occurring in commercial crops were race 0 and race 4, the latter predominating. However, from hybrids of *Solanum demissum* × *Solanum tuberosum* further races were identified as follows: race 1; race 2; race 1, 2; race 1, 4; and race 1, 2, 4.

During the past season, because of suitable weather conditions (Table 1), the spread of potato blight was extremely rapid, and damage to the commercial crop was extensive. At the Plant Breeding Station, Loughgall, many seedlings which had been free of blight in previous years were attacked. These included seedlings bred from parental material carrying one or more of the four major *R* genes.

Table 1. WEATHER RECORDS, LOUGHGALL, 1958

Data	June	July	August	September
Mean maximum temperature (° F.)	62	66	64	64
Mean minimum temperature (° F.)	48	51	51	52
Mean relative humidity (per cent)	82	82	84	89
Total rainfall (in.)	4·99	5·47	3·54	3·23
No. of days with 0·01 in. or more precipitation	20	23	22	20
Total sunshine (hr.)	113·2	143·5	107·9	89·1

Plants containing the *R*1, *R*2, *R*3 or *R*4 genes singly, and in all combinations, which had been obtained from Dr. W. Black, of the Scottish Plant Breeding Station, were grown in the field and made satisfactory growth before blight appeared.

The first genotype to be attacked early in July was the one containing the *R*4 gene. Blight was next recorded by August 6, on the *R*1 *R*4 and *R*1 genotypes. By August 20 plants containing the following genes were recorded as having been attacked by the pathogen: *R*1, *R*2, *R*4, *R*1 *R*2, *R*1 *R*4, *R*2 *R*4, *R*1 *R*2 *R*4, and *R*1 *R*3 *R*4. Blight developed very slowly on the *R*1 *R*3 *R*4 genotype and plants remained green for almost three weeks after the first lesion was recorded. At this date no blight was noted on the *R*3, *R*1 *R*3, or *R*3 *R*4 genotypes, possibly as a result of differences in field resistance and/or plant development, as well as the apparently low virulence of this race (presumably race 1, 3, 4).

Blight was recorded from all genotypes, including the *R*1 *R*2 *R*3 *R*4 genotype, by September 19.

It thus appears that under suitable conditions the development of races of the pathogen may be quite rapid, and the value of the hypersensitive reaction, governed by the presence of the *R* genes, would therefore be of limited practical application.

Breeding studies now in progress[2] suggest that field resistance resulting from the presence of minor genes will be of greater value for commercial breeding. Toxopeus[3] has suggested that high resistance of foliage is not sufficient unless accompanied by a high resistance of tuber to the pathogen. This has been confirmed at Loughgall, where some seedlings showing considerable foliage resistance to the pathogen have produced badly infected tubers.

K. G. Proudfoot

Plant Breeding Division,
Ministry of Agriculture,
Northern Ireland. Oct. 15.

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Feulgen Reaction in the Fucales

The Feulgen reaction has not been used to any great extent in cytological investigations of the larger brown algæ[1–4], possibly on account of the difficulty of obtaining consistent results. The following technique has now been applied successfully to growing vegetative apices and to developing receptacles of all the British members of the Fucales, with the exception of *Pelvetia canaliculata*, on which it has not yet been tried.

The material to be examined is cut into small pieces and fixed for 12–18 hr. in Karpechenko fluid. Fixation with acetic alcohol was also tried but often gave inconsistent results even in neighbouring cells of the same preparation. This may be due to the alcohol in the fixative causing hardening of the cell walls and thus preventing even penetration.

After fixation the material is thoroughly washed in running water. It is important at this stage to remove all traces of the fixative since it contains formalin, which gives a red coloration with Schiff's reagent[5]. If traces of the fixative are left, a red colour develops in the cell walls and in the cytoplasm and obscures the nuclear reaction.

The material is then transferred to distilled water, brought up to a temperature of 60° C. and then hydrolysed in *N* hydrochloric acid at 60° C. The time of hydrolysis varies in different species, but usually a reaction was obtained over a fairly wide range of hydrolysis times, usually of the order of 15–30 min. This maintaining of the reaction over an extended period has been correlated[5] with the presence of chromic acid in the fixative.

Hydrolysis is stopped by placing the material in cold distilled water, after which it is transferred to freshly made Schiff's reagent for 3–12 hr. After bleaching in three changes of freshly made sulphur dioxide water, hand sections are cut of the portion to be examined, mounted in sulphur dioxide water and squashed by firm pressure on the cover-slip. If permanent preparations are required, the coverslip is allowed to drop off into sulphur dioxide water and the preparation dehydrated and mounted in 'Euparal'.

In all the species examined this technique has given a good, sharp reaction. The two main drawbacks are the pigmentation of the plastids of the meristoderm and the outer cortex due to the fixative, and the fact that the technique may not macerate the material sufficiently for thorough squashing. Both these difficulties may be overcome by bleaching with hydrogen peroxide after fixation and before hydrolysis. The time of bleaching must be adjusted according to the nature of the material, delicate structures such as the receptacles of *Cystoseira granulata* requiring shorter periods than the apices of *Halidrys siliquosa*. Usually a period of 3–4 hr. in 20 per cent hydrogen peroxide has proved successful.

If bleaching has been used, then the time of hydrolysis must be considerably reduced, usually 7½–10 min. proving adequate.

This technique has been used successfully on both resting and dividing nuclei. In the former it has demonstrated a finely granular chromatin reticulum in species of *Fucus* and chromocentres in *Bifurcaria rotunda*, *Halidrys siliquosa* and *Cystoseira tamariscifolia*. All stages of division have given a sharp reaction in nuclei of both vegetative and reproductive cells.

M. Naylor

Department of Botany,
University of Hull. Oct. 21.

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Leaf-Enations in *Dahlia variabilis* Desf. induced by Tomato Spotted Wilt Virus

During a survey of virus-infected dahlias (*Dahlia variabilis* Desf.) in private and commercial gardens in south-west England, one diseased plant of the variety Jean was found bearing enations (Fig. 1) similar to those induced in some other solanaceous species by tobacco mosaic[1], tomato aspermy[2] and other viruses. The diseased plant was stunted and the foliage symptoms included irregular mottling and both ringspot and so-called 'oak-leaf' or chevron patterns. Oak-leaf and ringspot symptoms were occasionally present on the same leaf.

Ringspot symptoms in virus-infected dahlias have been attributed to tomato spotted wilt virus[3], dahlia ringspot virus[4] and dahlia yellow ringspot virus[4]. Oak-leaf symptoms have been attributed to dahlia oak-leaf virus[4], tomato spotted wilt virus[5] and, more recently,

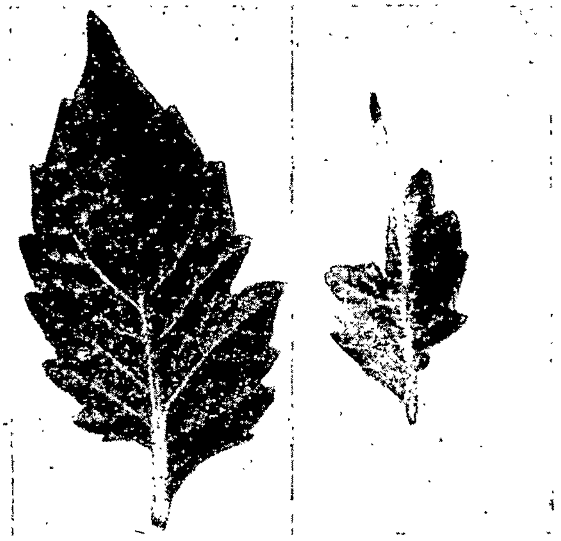

Fig. 1. Leaves of dahlia variety Jean showing enations

to a strain of cucumber mosaic virus[6]. However, experiments have shown that these enations in *Dahlia variabilis* var. Jean were induced not by a virus complex but by a strain of tomato-spotted wilt virus. When leaf extracts from the diseased plant were inoculated into a range of test plants, this virus was identified, but no other was isolated; no virus transmission to the same test plants resulted when leaf extracts were maintained at 43° C. for 10 min. before inoculation. Apterous females of the aphid *Myzus persicae* Sulz., given varying acquisition and test-feeding times, failed to transmit any virus from the diseased plant to young healthy dahlia seedlings, although in comparable experiments this species readily transmitted dahlia mosaic virus and cucumber mosaic virus from infected to healthy dahlias. When scions from the diseased plant were grafted on to the indicator variety, Willy Den Ouden, symptoms attributable to tomato spotted wilt virus were observed; when grafted to healthy plants of the same variety enations were rarely observed.

This is thought to be the first report of tomato spotted wilt virus inducing enation formation in any species of its extensive host-range, although strains of the virus have been intensively studied in relation to the pathology of tomato, tobacco and other crops.

There can be little doubt that oak-leaf, ringspot and yellow ringspot symptoms observed on dahlias in Britain and shown by these and other experiments to be induced by tomato spotted wilt virus are identical with those originally reported to be caused by separate non-sap-transmissible viruses in America[4]. Consequently, the terms dahlia oak-leaf virus[4], dahlia ringspot virus[4] and dahlia yellow ringspot virus[4] are considered to be invalid, and it is suggested that their use be discontinued.

A. A. Brunt*

Department of Botany,
University of Exeter.

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* Present address: West African Cocoa Research Institute, Ghana.

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PATHOLOGY

Effect of Neutral Red on Plaque Formation by Fowl Plague Virus

In a previous paper on the formation of plaques by fowl plague virus in Petri dishes of chick embryo cells, it was briefly reported that neutral red had the effect of reducing the number and size of the plaques formed by the virus if added to the cells at the beginning of an assay experiment, but a much smaller effect if added after three days[1].

A similar effect has been observed with poliomyelitis and western equine encephalitis viruses[2], and also with vesicular stomatitis virus[3].

A more quantitative study of this phenomenon suggests that the relation between the quantity of neutral red and the cell numbers is critical (Table 1), and also that time of reduction in plaque numbers is proportional to the concentration of neutral red (Table 2). The Rostock strain of fowl plague virus and the agar cell suspension plaque assay technique of Cooper[4] were used in all the experiments, as described in the earlier communication. Neutral red (Gurr) was used, and a standard volume was incorporated in the agar to make the final concentration in each Petri dish 1 : 10,000.

Table 1. Effect of Cell Numbers

Cells per Petri dish	Neutral red	Appearance on fourth day	Mean plaque count	Inhibition (per cent)
6×10^7	−	Plaques	71	—
6×10^7	+	Very small plaques	32	55
3×10^7	+	Toxic effect, with peripheral pallor. No plaques seen	—	—

Table 2. Effect of Varying Quantity of Neutral Red

Experiment No.	Quantity of neutral red	Mean plaque count	Reduction of plaque count (per cent)
1	Nil	61	—
	Standard	28	55
2	Nil	70	—
	Half-standard	51	27

The effect of neutral red appears early; that is, the reduction in plaque count is only slight if applied later, for example, on the third day. In this experiment (Table 3), no stain was added at the beginning, but six Petri dishes were stained on the third day and six on the fourth. All were read on the fourth day:

Table 3

Stained	Mean plaque count
Third day	22
Fourth day	26

In the experiments of Darnell *et al.*[2], the classical cell sheet technique was used, and they give reason for supposing that the neutral red acts on the infected cell, as adsorption of further virus is prevented by addition of agar overlay.

A. P. Waterson

Department of Pathology,
University of Cambridge.

Dec. 20.

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Local Inhibition by Lactation of chemically induced Breast Tumours in Mice of the *IF* Strain

THE *IF* strain of mice, established by Bonser[1], does not develop spontaneous breast tumours. However, it is very susceptible to the action of certain chemical carcinogens[2,3], developing a high incidence of tumours of the skin or breast when the chemicals are administered in an appropriate way. Dmochowski and Orr[4] showed that breast tumours so induced lacked the virus-like mammary tumour agent.

In previous studies of *IF* mice given methylcholanthrene it was found that, while the incidence of palpable breast tumours induced in virgin and forced-bred (unsuckled) mice was of the order of 70 per cent, no breast tumours were obtained in breeding mice which were allowed to suckle their young, provided the first lactation had begun before the mice received their first treatment with the carcinogen[5,6].

The experiment to be described here was performed in order to discover whether the inhibitory effect on induction of breast tumour of suckling the young was a direct local effect of lactation on the breasts concerned, or a result of the hormonal status of the lactating animals. The experiment was designed to provide breeding animals in which half the number of breasts would be suckled by young and the other half would not be suckled, though all would be subjected to the same hormonal influences. This was achieved by excising the nipples from the five breasts on one side only of 20 young adult *IF* female mice. The mice were then mated and allowed to breed freely, but the number of babies suckled was reduced to four if there were more than this number in a litter. After the first litter was born, eight fortnightly paintings of the mothers with 0·5 per cent methylcholanthrene in olive oil were begun, about 0·2 ml. being distributed over dorsal and ventral surfaces at each treatment. The mice were inspected once weekly for palpable tumours, and when these were large the animals were killed. At autopsy most of the palpable tumours were fixed and the pelts were removed and examined for non-palpable tumours. All suspicious lesions were removed for histological examination.

The mean survival of the 20 mice used from the first painting with methylcholanthrene was 28 weeks (range 19–45 weeks). The mean number of litters born after carcinogen treatment began was 3·15. Palpable breast tumours arose as subcutaneous lumps from the seventeenth week after the first painting with methylcholanthrene, many mice developing more than one. Some mice developed papillomas of the skin, and a few of these became malignant.

Table 1 shows the incidence of breast tumours in the mice. It will be seen that this was far greater in the non-lactating breasts. Only two palpable tumours were obtained on the lactating sides, whereas 31 palpable tumours were obtained on the non-lactating sides in 13 of the 20 mice. Almost all the tumours induced in this group of animals showed a very marked degree of squamous metaplasia. The two which arose on the lactating sides were entirely squamous, but it is considered that they may have arisen in breast tissue since they first appeared as subcutaneous lumps. The tumours with a marked squamous component grew more slowly than the typical adenocarcinomas with secretion which were previously induced with methylcholanthrene in virgin or forced-breeding mice of this strain. From histological study of the non-palpable nodules found in these mice, it is considered that many of the tumours probably arose from foci of squamous epitheliosis in the breast tissue, similar to those described by Pullinger[7].

Table 1. THE INCIDENCE OF TUMOURS INDUCED BY METHYLCHOLANTHRENE IN BREAST TISSUE OF 20 *IF* MICE SUCKLED ON ONE SIDE ONLY

Breast tumours	Number of mice with tumours on suckled side	Number of mice with tumours on non-suckled side
Multiple palpable	0	10
Single palpable	2	3
Non-palpable	1	2
None	17	5
Total mice	20	20
Incidence of mice with palpable tumours	2/20 = 10 per cent	13/20 = 65 per cent

The experiment described above indicates that the hormonal status of lactating animals is not responsible for inhibiting the chemical induction of breast tumours. The inhibition must, therefore, be a direct local effect of suckling on the breasts concerned. Further experiments are in progress to attempt to discover whether, or not, the inhibition by lactation results from excretion of the effective carcinogen in the milk.

I wish to thank the Birmingham Branch of the British Empire Cancer Campaign for support of this work.

JUNE MARCHANT

Cancer Research Laboratories,
Department of Pathology,
Medical School,
Birmingham 15.

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Increase of Viral Hæmagglutinability of Red Cells of the Mouse after Treatment with Formalin

Clark and Nagler[1] found that the red cells of the mouse did not react very well with viral hæmagglutinin. Flick[2,3], and later on Cox and Pirtle[4], introduced the use of human red cells treated with formalin in the study of hæmagglutination by influenza virus. We found, while using formalin to stabilize the red cells of fowl and mouse for viral hæmagglutination, that the hæmagglutinability of those of the latter was considerably enhanced, particularly for certain types of influenza virus.

A slight modification of the method described by Cox and Pirtle[4] was used for preparing the preserved fowl cells and preserved mouse cells with a little modification. Mouse cells were obtained from pooled blood of a Swiss strain of mice. 100 ml. of citrated blood (with 1 per cent sodium citrate) was diluted with an equal volume of physiological saline. 40 ml. of a 50 per cent solution of isotonic formalin (20 ml. of pure formalin with 20 ml. of 1·70 per cent sodium chloride) was then added to the diluted blood. This mixture was then placed in a water-bath at 37° C.

For preparation of preserved fowl cells and preserved mouse cells like those used by Cox and Pirtle, the cells were mixed with formalin and heated twice for 2 hr. each time. Another type of cells was prepared by mixing with formalin in the same way and then heating the mixture once for 6 hr. at the same temperature. After heating, the cells were washed three or four times with about 20–30 vol. of physiological saline to remove formalin as completely as possible, and a 0·5 per cent suspension was then prepared with these cells in physiological saline for the tests provided the cells were not auto-agglutinating.

The diluted blood was treated with carbon monoxide gas before the addition of formalin to preserve the familiar red colour of the cells instead of the brown coloured cells obtained by the usual technique. This was found to facilitate the reading of the results of hæmagglutination by Fauconnier[5].

Fresh fowl and mouse cells were washed three times in physiological saline before preparing a 0·5 per cent suspension for the tests along with the preserved cells.

The strains of viruses employed in this study were egg-adapted strains of the laboratory and were used in the form of infected allantoic fluid which had been clarified by centrifuging. Salk's classical technique[6] was used for testing the hæmagglutinability of various cells. Serial two-fold dilutions in two rows starting from 1 in 2 and 1 in 3 of the virus in physiological saline were mixed with an equal volume of 0·5 per cent red cells. The reactions were always carried out at 4° C. and the results were read after 6 hr.

A typical example of the results of the hæmagglutination tests with different red cells and various virus strains is shown in Table 1.

Table 1 shows that most of the viruses included in this study exhibit a rise of the hæmagglutination titre with the mouse red cells treated with formalin as compared with the fresh mouse cells. The rise is, however, more significant with the three strains of influenza *B*. These three strains of influenza *B* seem to possess little or no hæmagglutinin for fresh mouse cells but could agglutinate the formalin-treated mouse cells to a fairly high titre which compared favourably with the titre obtained with the fresh fowl cells. Almost a similar phenomenon was also observed with a local strain (*BOS*) of mumps virus. Even with the very sensitive red cells of the fowl a slight but consistent increase in titre was found when the cells were preserved with formalin. Table 1 also shows that the period of heating of formalin–red cell mixture plays an important part, as a higher titre was usually obtained with the cells heated for 6 hr. than the titre with the cells heated for 4 hr.

Table 1. HÆMAGGLUTINATION TITRE (RECIPROCALS) WITH DIFFERENT TYPES OF RED CELLS

Strains of virus	Chicken cells			Mouse cells		
	Fresh (untreated)	Preserved		Fresh (untreated)	Preserved	
		Heated for 4 hr. (Cox)	Heated for 6 hr.		Heated for 4 hr. (Cox)	Heated for 6 hr.
A-PR8	2,048	4,096	8,192	128	2,048	4,096
A-WS	2,048	2,048	4,096	512	4,096	4,096
B-Lee	2,048	2,048	4,096	< 2	192	1,536
B-Vig.	512	718	1,024	2	128	512
B-Eng./54	2,048	2,048	8,192	2	512	2,048
A./Asian/57	512	512	512	16	128	128
A'FMI	1,024	1,024	2,048	64	256	512
A' Thion.	2,048	2,048	4,096	1,024	1,024	4,096
D-Sendai	4,096	4,096	8,192	1,024	2,048	4,096
Swine	—	—	—	16	32	64
Mumps (*BOS*)	256	512	1,024	< 2	64	256

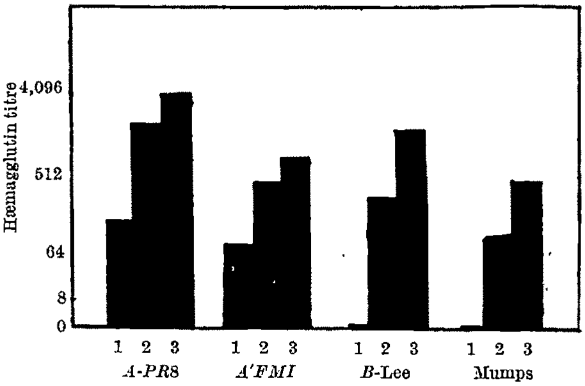

Fig. 1. Differences in hæmagglutinability of fresh and preserved mouse cells: 1, fresh mouse cells; 2, preserved mouse cells heated for 4 hr. (Cox); 3, preserved mouse cells heated for 6 hr.

It appears that formalin under certain well-defined conditions can confer the property of hæmagglutinability on certain red cells which are normally not sensitive to viral hæmagglutinin, and can enhance the same property in some normally sensitive red cells.

The mechanism of action of formalin on the red cells will have to await further investigation. It was found during this work that prolonged heating after addition of formalin to red cells brought about their auto-agglutination in physiological saline though they were found to be stable at a lower ionic concentration. Possibly the process of preparation of formalin-preserved red cells enhances their hæmagglutinability by lowering their surface charge.

This finding shows that it may be possible to demonstrate virus receptors in red cells of other species of animals after treatment with formalin which normally do not react well with viral hæmagglutinin. Similarly, hitherto undiscovered hæmagglutinating virus may also be discovered with the formalin-treated cells and attempts are now being made in this direction in this laboratory.

B. FAUCONNIER
D. BARUA

Centre National de la Grippe,
Institut Pasteur,
28 rue du Docteur Roux,
Paris 15.
Dec. 30.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 2

British Society for the Philosophy of Science (in the Council Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. Grey Walter: "The Study of Complex Systems".

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. G. T. Lane: "Some Experiences of River Control in Africa".

Society of Chemical Industry (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. R. A. E. Galley: "Colonial Research—Products and Pesticides" (Jubilee Memorial Lecture).

Tuesday, March 3

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. J. H. Green: "Aspects of Polymer Fractionation".

Royal Society of Medicine, Pathology and Radiology Sections (at 1 Wimpole Street, London, W.1), at 8 p.m.—Discussion on "Changes Produced in Tissues by Irradiation". Opening Speakers: Dr. H. J. G. Bloom, Dr. R. H. Mole and Dr. A. Glucksmann.

Wednesday, March 4

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. H. E. Snow, C.B.E.: "Looking Ahead. On the Threshold of Our Second Century".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5.30 p.m.—Mr. H. H. Lamb: "Our Changing Climate, Past and Present" (Third Evening Discourse).

Prestressed Concrete Development Group (at the Royal Commonwealth Society (Craven Street entrance), London, W.C.2), at 6 p.m.—Prof. H. Rüsch (Institution of Technology, Munich): "How Can the Advantages of Prestressed Concrete Best be Utilized ?"

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Meeting on "The Diagnosis of the Causes of Corrosion Failures".

Thursday, March 5

University College (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. E. Wiesenberg: "The Dead Sea Scrolls: Where do they Come From ?"

Royal Society (at Burlington House, Piccadilly, London, W.1) at 4.30 p.m.—Mr. E. M. Nicholson: "The Nature Conservancy as a Research Council".

Royal Society of Medicine, United Services Section (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "Some Aspects of Naval Aviation Medicine". Opening Speakers: Surg.-Capt. F. W. Baskerville, Surg.-Lieut. P. C. Barrington, Surg.-Lieut.-Cdr. I. H. Colley and Surg.-Cdr. E. Boyd Martin.

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Mr. Charles Mountford: "The Art of the Australian Aborigines and its Place in their Lives".

Institute of Refrigeration (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. T. van Heile: "Applications of Refrigeration to Horticultural Produce in the Netherlands".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. P. Pitts: "The Reliability and Life of Impregnated Paper Capacitors".

Royal Anthropological Institute (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. Peter Willmott: "Mothers and Daughters: a Discussion of Kinship in Contemporary Britain".

Institution of Mechanical Engineers, Industrial Administration and Engineering Production Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Engineering Standards—Development and Use".

Society of Instrument Technology, Data Processing Section (at Manson House, Portland Place, London, W.1), at 6 p.m.—Symposium on "The Use of Data Recorded on Industrial Plant".

Society of Chemical Industry, Microbiology Group (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Prof. G. F. Gause (Academy of Medical Sciences, Moscow): "The Microbe's Contribution to Cancer Research".

Polarographic Society (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Polarographic Problems Encountered in Agricultural Studies" introduced by Mr. R. Peak.

Friday, March 6

Association of Applied Biologists (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 10.45 a.m.—General Meeting. 11 a.m.—Symposium on "Recent Advances in Plant Propagation".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 10.45 a.m.—Symposium on "Experimental Taxonomy of Vascular Plants". Speakers include Prof. D. H. Valentine, Dr. D. A. Wilkins, Dr. J. D. Lovis, Dr. S. Walker, Miss J. Buchanan, Dr. J. Savidge and Dr. V. H. Heywood.

Society for Analytical Chemistry (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Annual General Meeting, followed at 3 p.m. by the Address of the Retiring President, Dr. J. H. Hamence.

University College (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. J. Folch-Pi (Harvard Medical School): "Brain Lipoproteins and Proteolipids".* (First of two Special University Lectures in Biochemistry. Further lecture on March 9).

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. J. H. Horlock: "Approximate Equations for the Properties of Superheated Steam".

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. A. E. Henshall: "The Use of Antistatic Agents in Textile Processing".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Ronald King: "Metal Surfaces".

Saturday, March 7

Nutrition Society (at the Royal Veterinary College, Royal College Street, London, N.W.1), at 10.15 a.m.—Symposium on "Rumen Function".

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Alfred Leutscher: "Reptiles as Pets".*

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant, Grade A (suitably qualified to teach mathematics to students in Preliminary, Engineering Trade Courses, and in the first year of the National Certificate Course), in the Mathematics Department—The Principal, Coventry Technical College, Butts, Coventry (March 6).

Head (with high qualifications in pharmacy and wide experience in both teaching and research) of the School of Pharmacy—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (March 7).

Johns Manville Research Scholar (man or woman, with a B.Sc. honours degree or equivalent) in the Department of Chemistry, for work of a chemical and crystallographic type on silicates, especially of the chrysotile group—The Secretary, The University, Aberdeen (March 7).

Lecturer in Medical Chemistry in the Department of Medicine—The Registrar, The University, Manchester 13 (March 9).

Assistant Lecturer (preferably with some knowledge of numerical analysis) in the Department of Mathematics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (March 11).

University Demonstrator (with an honours degree in chemistry or agricultural chemistry) in Soil Science—The Secretary, School of Agriculture, The University, Cambridge (March 11).

Assistant Lecturer, Grade B (preferably with teaching and research experience), in the Department of Physics—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (March 14).

Junior Lecturer (preferably interested in physiology or in mycology) in Botany—The Registrar, Trinity College, Dublin, Ireland (March 14).

Lecturer in Zoology—The Principal, St. Anne's College, Oxford (March 14).

Lecturer or Research Assistant in Bacteriology and Virology—The Registrar, The University, Sheffield (March 14).

Lecturer (with experience in teaching physical science, preferably chemistry) in Education—The Registrar, The University, Nottingham (March 14).

Chemist (with an honours degree or equivalent in chemistry or chemical engineering, several years experience of chemical plant management, preferably in plants involving radioactive processes, and a good knowledge of the novel techniques used in the industry), to control a group of chemical plants involving the processing of radioactive materials, and to be responsible for the safe and efficient operation of these plants—The Personnel Manager, U.K.A.E.A., Industrial Group, Experimental Reactor Establishment, Dounreay, Thurso, Caithness, Scotland, quoting Ref. 2973/T (March 16).

Lecturer in Animal Ecology, or Lecturer in Plant Ecology—The Secretary, The University, 36 North Bailey, Durham (March 16).

Principal Scientific Officer (preferably 40 to 45 years of age, with wide experience in biological research and preferably also in administrative/scientific work), to take responsibility for the Conservancy's Conservation Branch in England—The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1 (March 16).

Demonstrator in Physics, to assist the teaching staff in practical classes and in tutorials—The Registrar, Manchester College of Science and Technology, Manchester 1 (March 21).

Lecturer in Metallurgy—The Registrar, The University, Sheffield (March 21).

Analyst (with a degree in chemistry or biochemistry, or considerable experience in analytical chemistry) in a hospital biochemistry laboratory—The Registrar, The University, Leeds 2 (March 28).

Senior Lecturer in Nuclear Physics—The Secretary, The University, 38 North Bailey, Durham (March 28).

Assistant Lecturer in the Department of Zoology—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (March 31).

Associate Professor in Engineering at Newcastle University College, University of New South Wales, Australia—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (Australia, March 31).

Junior Lecturer (with qualifications in invertebrate palæontology) in Geology—The Registrar, Trinity College, Dublin, Ireland (March 31).

Lecturer in the Chemistry of High Polymers in the Department of Textile Industries—The Registrar, The University, Leeds 2 (March 31).

Lecturer or **Assistant Lecturer** (man or woman, with an honours or special degree in statistics, or in mathematics with qualifications in statistics) **in Statistics**—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (April 1).

Assistant Lecturer in Zoology—The Registrar, University College, Singleton Park, Swansea (April 4).

Reader in Applied Thermodynamics at Imperial College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 8).

Reader or **Senior Lecturer** (with a degree or higher degree in engineering of a recognized university, together with design experience in industry and teaching experience at university level in design subjects) **in Mechanical Engineering** at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 10).

Berkeley Bye-Fellow in the Natural Sciences or in Medicine—The Registrar, Gonville and Caius College, Cambridge (April 30).

Research Student (with a first degree in mathematics or theoretical physics, and wanting to read for a D.Phil. degree) at the Mathematical Institute, to work in electronic structure of metals under the direction of Prof. C. A. Coulson, F.R.S.—The Secretary, Mathematical Institute, The University, 10 Parks Road, Oxford (April 30).

Shell Student in Geophysics—Head of the Department of Geodesy and Geophysics, The University, Madingley Rise, Madingley Road, Cambridge (June 1).

African Pyrethrum Research Fellow (with at least a good honours degree in entomology, biochemistry or zoology), to study certain problems related to the use of Pyrethrum as an insecticide on field and horticultural crops—The Registrar, The University, Nottingham.

Computer (with experience of electronic digital machines), to join a research team studying biomolecular structure by X-ray crystallography—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1.

Demonstrator in Crop Husbandry, and a **Demonstrator in Animal Physiology** at the School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

Head (graduate, preferably with both teaching and industrial experience) **of the Science Department**, Grade III—The Principal, Ewell County Technical College, Reigate Road, Ewell, Surrey.

Lecturer in Physics—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Lecturer (with appropriate academic qualifications together with a wide industrial experience in yarn manufacture, and preferably experience in teaching and/or research) **in Spinning**—The Registrar, Institute of Technology, Bradford 7.

Mining Geologist (with a first- or good second-class honours degree in geology or mining geology, or equivalent qualification) in the Federation of Nigeria, for the detailed examination and appraisal of mineral deposits including the supervision of drilling and prospecting operations—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/011.

Organic Chemist (Graduate), to join a team investigating a problem in the field of wood chemistry—The Director, Arthur D. Little Research Institute, Inveresk Gate, Musselburgh, Midlothian, Scotland.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

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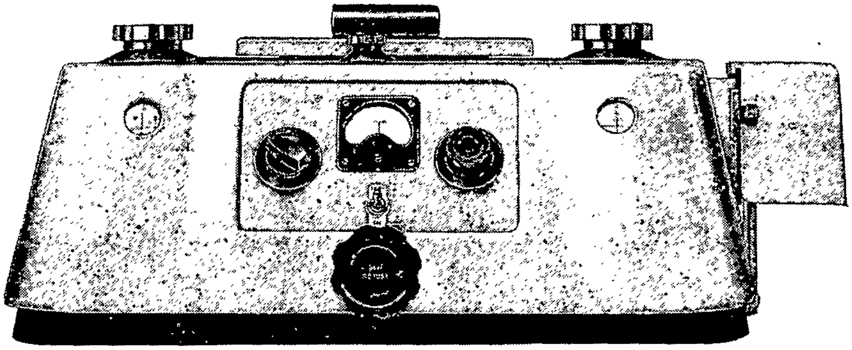

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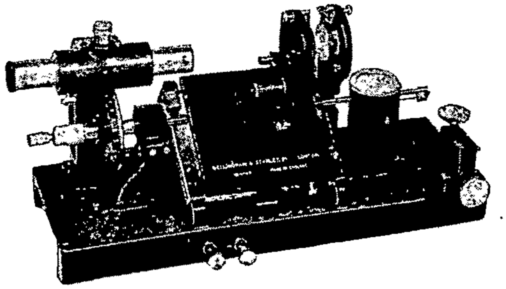

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EDUCATIONAL ADVANCEMENT AND THE UNDER-DEVELOPED COUNTRIES

SOME decisions taken at the Commonwealth Trade and Economic Conference which met in Montreal last September have already been discussed in these columns (see *Nature*, December 20, p. 1693). Their full significance is probably only to be appreciated in the light of the very large gap that exists between the standard of life in Asia and the standard of life in North America or Europe. The existence of that gap is, of course, well known, and was brought out by Prof. P. M. S. Blackett in his presidential address in Dublin to the British Association ; but, in pointing that out at Montreal, it was emphasized that the essential problem in Commonwealth relations is the widely different rate of economic progress between the highly industrialized and the under-developed countries, and Sir David Eccles reminded the House of Commons on November 4 that this gap is growing wider every year. That is less well known and is extremely dangerous, and it is this sense of falling further behind that disturbs the poorer nations in the free world and may induce policies that threaten their stability.

At Montreal, said Sir David, the Conference was asked what would happen if the living standards in China rose appreciably faster than the living standards in India and Pakistan. This is one of the most serious questions in the world to-day, and the Commonwealth Conference was a success because it accepted the challenge of the widening gap and devoted its best endeavours to considering how the under-developed countries could be further helped to increase their rate of progress. Even if we and other creditor countries in the free world give the under-developed countries all the aid we can, it is unlikely to suffice to finance a tolerable rate of development. This is why they need to increase their export earnings, and the Haberler report has shown that such exports must include an increasing proportion of manufactured goods.

Unless, Sir David continued, the United States and Europe buy more goods from the under-developed countries, it is hard to see how these countries can respect and adhere to the Western economic system. It is here that the real Soviet challenge lies, for once countries in Asia and Africa are bound to the Soviet block by strong economic ties, they are unlikely to remain neutral, far less align themselves with Western democracy. The practical measures concerted at Montreal were designed to meet this major issue, and they attest in particular the willingness of the United Kingdom to make the major contribution to Commonwealth development.

While the Conference recognized that development is vital not only to the economic expansion of the Commonwealth but also to the whole structure of relationships within the Commonwealth and to the maintenance of democratic institutions, the closing of this gap in standards of living was seen as a human and moral responsibility which members of the Commonwealth share with other countries. In particular, Sir David Eccles referred to the fact that no group of nations in the free world can either resist the Communist challenge from without or achieve balanced progress within its own ranks unless the United States plays a major and consistent part in maintaining economic activity and in opening its markets to the free world. We are forced back again on the interdependence of the free world as plainly as were Mr. Macmillan and President Eisenhower in their meeting during the previous autumn.

Mr. Nixon's remarks on this point in his speech at Guildhall, with its tribute to the "dedicated and effective work of the superb Colonial administrators" of the British Empire, were particularly welcome in this connexion, both as evidence of a growing understanding of the British contribution and for the reaffirmation of Mr. Nixon's deep concern to see that American foreign aid is maintained effectively in the countries which the U.S.S.R. is seeking to influence. Indeed, it is increasingly apparent that the relation of development to security is recognized, and that it is appreciated that trade and aid are important factors in a real defence policy. President Eisenhower, for example, coupled his request to Congress last year for 3,942 million dollars for the foreign aid programme with a reminder that any significant cut in this figure could lead to a massive increase in military spending by the United States, higher taxes and an increase in the rate of conscription, due to severe dislocation and impairment of the power of the free world, and the crumbling, under Sino-Soviet pressures, of United States strategic overseas positions, which might be forced back towards its own shores.

It is not, of course, only to the United States that the value of the aid programme to a country is many times greater than what it costs that country ; but in spite of what was said by the Prime Minister at the Lord Mayor's banquet and by him and Mr. Nixon at Guildhall, it will not be too easy to convince the ordinary citizen of this close connexion, and to bring home to him how important it is that assistance to the under-developed countries should be forthcoming on an adequate scale, even at the cost of some sacrifice in the standard of living in the more advanced industrialized countries. The White Paper stressed also the importance of providing the under-developed countries with opportunities to expand their trade on a stable basis, thereby increasing their export earnings and improving their prospects of attracting external capital. Neither in the House of Lords nor in the House of Commons, however, did the implications in the way of sacrifices demanded of the more industrialized countries receive much attention, though further reference to the gap was made in a debate in the House of Lords on December 18, notably in a speech by Lord Strang, who directed attention to the emphasis placed by Mr. Nehru on the grave political implications of the gap in his opening speech at the meeting of the International Bank and Monetary Fund at New Delhi.

In his speech in opening the debate on Commonwealth and international economic problems in the House of Commons on December 2, the Chancellor of the Exchequer, Mr. Heathcoat-Amory, dealt with the problem of development at some length and pointed out that the highly developed countries had expressed at Montreal a strong desire to expand the substantial help they were already giving to other Commonwealth countries. Some 70 per cent of new overseas investment in the Commonwealth since the War has come from Britain, but Mr. Heathcoat-Amory also pointed out that any country which wishes to encourage long-term private investment should make sure that conditions are favourable, and he also emphasized that the highly developed countries can only give such help if their own economies are maintained strong. Since the Montreal Conference the Government has announced, at the recent meeting of the Consultative Committee for the Colombo Plan, that the United Kingdom would make available a further £2 million for technical assistance.

All this stresses the vital importance of educational development on both sides, and Mr. Heathcoat-Amory characterized the decision on education, along with those on the improvement of telecommunications and the improvement of Commonwealth economic consultation, as the three imaginative decisions taken at Montreal. As in the House of Lords on November 4, the proposals for Commonwealth scholarships and fellowships and for an educational conference was warmly welcomed, and that their significance is appreciated appears from the stress laid by Mr. J. E. Ramsden on the teaching of English and the importance of getting more teachers of English. Sir David Eccles said, in reply, that this part would be much in mind at the conference, which would deal with the provision of teachers as well as the scheme for university students. Mr. Ramsden also referred to the importance of an adequate supply of English books, and particularly welcomed the emphasis laid in the report on training in the humanities as well as in science, stressing the relation of all the educational proposals to technical development and the value of a two-way traffic in scholars and students between the overseas countries of the Commonwealth and Great Britain.

Mr. M. MacPherson also stressed the importance of not limiting the conference on education to universities and students at an advanced level. Mr. Heathcoat-Amory had stated that already 10–12 per cent of the total places in universities and technical colleges in Britain are allotted to overseas students, two-thirds of whom come from the Commonwealth, and Mr. MacPherson suggested that it is important to get a general picture of educational needs and opportunities in the Commonwealth, so that the magnitude of the demand at the university and professional level can be assessed and the real priorities seen. What is implied in the allocation of 10–12 per cent of the places to overseas students should be known and appreciated. Mr. J. Johnson, for example, who maintained that the struggle between East and West would be determined not by arms or conflict, but by the standard of education, and that our biggest investment should be in educated people, thought that present standards in our overseas universities are much too high.

The decision as to which stage should receive priority is by no means simple. Even where the most pressing need is for primary education, the additional teachers needed involve a simultaneous effort at least in secondary education to provide them; nor can the country itself train them without expansion at the training college or university level. Indeed, it is in this interlocked situation that the contribution of the Inter-University Council for Higher Education in the Colonies has been so outstanding, and, quite apart from the continuing demand for places for overseas students in British universities and technical colleges as our own programme of expansion proceeds, the scarcity of scientific and technical manpower relates the needs of the overseas territories to those of Britain. Neither educational expansion nor technical assistance can be planned without regard to available resources in man-power, finance and equipment.

Here, therefore, as the report on the Montreal Conference sufficiently shows, educational advance overseas is related to the programme of expansion in Britain, just as much as are technical assistance and Colonial research, for example. It may well be that besides increasing economic aid to the under-developed countries, we need to find some new form of international organization to channel and co-ordinate all aid programmes. The Special United Nations Fund for Economic Development might have served, had the United States been willing to accept a plan that left the distribution of aid largely in the hands of the recipient countries themselves.

Nevertheless, the breakdown of that proposal only emphasizes a further dual aspect of the dependence of any such economic offensive on education. It is not simply that educational expansion, both in Britain and in other advanced countries, is required to provide the trained man-power of all kinds that technical aid and development demand, just as much as in the under-developed countries; it is the condition of their being able to utilize such assistance and to promote development schemes. On such educational development depends the formation of a body of public opinion and understanding in the advanced countries which will accept and sustain the programmes with all the sacrifices they entail and, in the under-developed countries, provide the climate of opinion and stability necessary both for continuity and to attract the necessary financial capital.

Nor is this any less true of the policies required to establish and maintain national food reserves in the under-developed countries set out in a recent report of the Food and Agriculture Organization*.

It is in this context that we should welcome the attention now being given in the United States to research in the tropics and particularly in Africa. Lord Hailsham's remarks to the Canada Club on November 18 are also worth noting. Canada, it may be recalled, announced at Montreal that it proposed to make 10 million dollars available as economic assistance to the West Indies over the next five years, to include provision of a second ship for the West Indies inter-island shipping service. Lord Hailsham suggested that, if the Commonwealth is to fulfil its purpose, relations must develop between the individual members of the Commonwealth on a scale almost comparable to their existing relations with Britain. Accordingly, the Commonwealth needs to think out afresh the nature and purposes of the association between its members, and the means by which that association can be enhanced.

Lord Hailsham referred to three urgent needs: to understand clearly the later development of the Commonwealth; to diversify and enrich inter-Commonwealth relations; and to foster, on a non-political level, the closest contact between individuals, business associations and professions. In particular, he stressed the need to share and think out afresh the vast task of investment and assistance in scientific research and technical education, if only to ensure that assistance is freed from any suspicion of political dependence. Finally, he emphasized the dependence of the Commonwealth on certain moral and spiritual values which are not exclusive but universal to mankind. These values are those in which science in particular flourishes and, if at this juncture technical assistance offers a particular challenge to the scientist and technologist in Britain, in the measure in which they seek to answer the challenge as indicated at Montreal they will be furthering and safeguarding the advance of science itself.

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* Food and Agriculture Organization of the United Nations. FAO Commodity Policy Studies No. 11: National Food Reserve Policies in Underdeveloped Countries. Pp. vi+70. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1958.) 5*s*.; 1 dollar.

EARLY TEXTILE TECHNOLOGISTS

The Strutts and the Arkwrights, 1758–1830

A Study of the Early Factory System. By R. S. Fitton and A. P. Wadsworth. Pp. xii+361+19 plates. (Manchester: At the University Press, 1958.) 35*s*. net.

"WE must reason from what we know, and inventing is only looking at all sides of a thing and putting it in different points of view, and by long habit and a great store of ideas this becomes almost mechanical." So William Strutt, F.R.S., addressed his son, then a pupil at a Nonconformist academy, in 1818. Earlier he had expressed the hope that "in a few years you will be recommended for the R.S.". The son's felicity was obtained in other ways: he married the daughter of a bishop and was created Baron Belper in 1856. No apter tribute could have marked the centenary of the invention of the Derby rib machine by his grandfather, Jedediah Strutt.

Nonconformity had few families of such dynastic tenacity. Jedediah (1726–1797), son William (1756–1830) and grandson Edward (1801–1880) were all in their way remarkable. Jedediah, backed by dissenting hosiers at Derby and another at Nottingham, launched into manufacturing silk hose at Belper, Milford and Derby. By 1769, when he was forty-three years old, he was prosperous enough to become a backer himself. His protégé and partner, Richard Arkwright, had a roller-spinning machine, and two years later they built a factory at Cromford. This, as R. S. Fitton and A. P. Wadsworth remark in their closely documented and well-reasoned study, "was one of the turning points in the history of the factory system". It was the first of the cotton factory villages that were to change the landscape of the north of England during the next half-century. Arkwright prospered, too, and built Birkacre, near Chorley—the first to be put up outside Derbyshire—and Nottingham, Worksworth, Manchester, Matlock Bath and Bakewell, and in turn he financed Samuel Oldknow, who was manufacturing muslin. Though the Strutt – Arkwright partnership seems to have dissolved in 1781, the complex of a half-dozen factory colonies were all within a dozen miles of each other and the Strutt colonies soon outpaced the Arkwrights. Jedediah died sixteen years later and was buried in the Unitarian Chapel at Belper. His three sons, led by William, transformed the business and the cotton mills. The power of the Belper Mills was afforded by the turbulent Derwent, and a writer in "Rees' Cyclopædia" described them as "the most complete we have seen in their dams and waterworks". By 1820 fourteen acres of water had been added to the Derwent reaches just above Belper Bridge.

The water-driven machinery never stopped except for the dinner break. In these integrated factory colonies breakfast, dinner and tea were provided and, when national occasions demanded, brass bands, the players being on the pay roll. The factory colonies of the Strutts were classic examples of benevolent despotism on a small scale, and it is interesting that Samual Slater, 'founder' of the American cotton industry, served his apprenticeship with the Strutts and that William Harriman was their first customer in America. Harriman's great-great-grandson was to become ambassador to Great Britain and governor of New York.

Shrewdly the Strutts learned by others' misfortunes. After fire had destroyed one of Arkwright's mills in 1781 and the famous Albion Mills in London in 1791, they built a mill at Derby and a warehouse at Milford using iron-framed buildings paved with brick. By 1803 they were building a mill at Belper which was completely iron-framed and internally heated. Not the least of the interesting contributions which Dr. Fitton and the late Mr. Wadsworth have made to the social history of technology is their perceptive and detailed account of the way in which emergent cotton technology married up with parallel developments in other fields. Well might Ure, in his "Philosophy of Manufacturers" (1835), direct attention to their little co-operative society which had a thirteen years trial before being abandoned. Close-knit and clean, their cotton colonies were the communes of the Peak, with the Strutts as benignant taskmasters.

W. H. G. ARMYTAGE

VIRUSES, GENES AND ANTIGENS

Advances in Virus Research

Vol. 5. Edited by Kenneth M. Smith and Max A. Lauffer. Pp. ix+376. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 9.50 dollars.

PROBABLY what most people first want to know about a collection of review articles is: Who is writing and what about? This is easily answered: J. B. Brooksby on "The Virus of Foot-and-Mouth Disease"; Herbert A. Wenner on "Psittacosis-Lymphogranuloma Group of Viruses"; Gunther S. Stent on "Mating and Reproduction of Bacterial Viruses"; G. Bertani on "Lysogeny"; Ph. L'Héritier on "The Hereditary Virus of Drosophila"; Forest Fulton on "The Measurement of Complement Fixation by Viruses"; Anne Buzzell and Martin Hanig on "The Mechanism of Hemagglutination by Influenza Virus"; but to comment usefully on this collection in a brief notice is more difficult. From the many facts and much speculation, what perhaps emerges most obviously is how disparate is knowledge about different groups of viruses and how varied are the techniques and types of approach to their study.

The first two articles are primarily concerned with viruses as pathogens, summarizing general properties, host ranges and the like. Information on the constitution of members of the Psittacosis group is much needed, for these are exceptional in that some diseases they cause are amenable to chemotherapy, suggesting they may be chemically more complex than smaller viruses. The next three articles are concerned with pathogenicity only as an experimental tool. The two on bacteriophages are excursions into radiobiology, genetics, the replication of nucleic acid, and the relationships between nucleic acid and protein synthesis, subjects for which these systems provide elegant experimental material and results rich in their scope for speculation. The juxtaposition of the article on the *Drosophila* virus and lysogeny stresses the similarities between the two systems and makes almost irresistible the temptation to extrapolate from the knowledge about bacteriophages to the constitution of the *Drosophila* virus about which nothing is known. That this virus was for long accepted as an example of cytoplasmic inheritance vividly illustrates how difficult it can be to define the boundaries between genetics and pathology.

The last two articles are not at all concerned with viruses as pathogens, but with other properties useful in assays. Fulton's scholarly analysis of the complement fixation test would be equally, perhaps more, appropriate to a volume on serology. However, there was no need to justify its inclusion for such questionable reasons as that viruses can rarely be obtained concentrated enough to use other serological methods and that virus workers are prejudiced against complement fixation. The precipitin test is used successfully with many viruses, and complement fixation is mentioned too often in the first two articles in this volume to suggest any strong prejudice against it. A third reason he offers is that "the complement test is both easier and more specific than hemagglutination techniques", the subject of the last article. Fulton says "Hemagglutination is bedevilled by non-specific inhibitors, and is a much more sophisticated technique than it first appears". In this, Buzzell and Hanig seem to agree, for they say "the ostensible simplicity of the hemagglutination reaction is, in reality, confused by a mass of diverse, and often contradictory evidence. Any mechanism which might be proposed to explain these divergences must be exceedingly flexible and endowed with so many parameters that it may be expected to explain anything". A cynic might be tempted to add that this is also true of mechanisms proposed for some other phenomena described in this volume.

Probably few virus workers will read all these articles with interest, but even fewer will find nothing of interest. The authors deserve credit for discussing their subjects critically and not simply summarizing all published work. It is less praiseworthy that reading is often unnecessarily tedious because some have rarely used one word when they could employ three.

F. C. BAWDEN

CHEMISTRY OF THE STEROIDS

Chemistry of the Steroids

By Prof. Charles W. Shoppee. (Organic Chemistry Monographs.) Pp. vii+314. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 50*s.*; 9 dollars.

FROM the author's preface it would appear that this volume has been written with the object of providing both a concise account of our present knowledge of the chemistry of the steroids and a more complete one of recent work, particularly when this has appeared since existing treatises on the subject were compiled. It is thus apparently intended to serve the dual purpose of a text-book and a work of reference. In the latter capacity it will prove invaluable, for it summarizes most of, if not all, the reactions which the individual steroids undergo and is liberally provided with references to the original sources. As a text-book it also contains many valuable features. It is useful to have collected together in one volume the principal data on which the accepted structures, conformations and configurations of the individual steroids are based; it is advantageous to possess brief summaries, translated in terms of present-day notation, of the fundamental contributions made by Windaus and Wieland to our knowledge of the structures of the sterols and bile acids; and it is convenient to have available outlines of the methods by which so many partial or total syntheses of important steroids have been effected. But its value as a text-book is somewhat diminished by the interspersing throughout the text of long passages—no doubt necessary in its capacity as a reference book—which consist of catalogues of chemical reactions. These make monotonous reading and destroy the continuity of the subject-matter.

As the title indicates, the book deals solely with the chemistry of the steroids. Nevertheless, brief statements of the functions or physiological activities of the individual compounds or groups are, when known, necessarily made. The subject-matter has been clearly and, so far as I can ascertain, accurately presented. Attention may, however, be directed to the following minor points:

The statement in the introductory chapter that the steroids are, "for the most part, saturated natural products . . ." appears to be misleading. For, while it is true that the bile acids follow this 'rule', the sterols, steroid hormones and other steroids do not.

In the chapter describing the sterols, each individual sterol is described in a separate section. Coprosterol (coprostanol) is not so treated, although it is mentioned elsewhere incidentally in the text. As a naturally occurring sterol, coprosterol should surely have been accorded individual treatment.

The occurrence of ergosterol in ergot, from which fact it derives its name, might have been mentioned. It is true that it also occurs in yeast, which now constitutes its chief source.

Finally, it seems a pity that a chapter has not been devoted to the steroid alkaloids, particularly as individual members of this group are occasionally mentioned in the text. E. STEDMAN

POLYMER CHEMISTRY

The Kinetics of Vinyl Polymerization by Radical Mechanisms

By Dr. C. H. Bamford, Dr. W. G. Barb, Dr. A. D. Jenkins and Dr. P. F. Onyon. Pp. xii+318. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 50*s*.; 8.80 dollars.

The Effects of Ionizing Radiation on Natural and Synthetic High Polymers

By Frank A. Bovey. (Polymer Reviews, Vol. 1.) Pp. xiii+287. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 8 dollars.

Physical Chemistry of High Polymers

By Dr. Maurice L. Huggins. Pp. 175. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 52*s*. net.

THE mechanism of vinyl polymerization has probably been studied in more detail than that of any other kind of chemical reaction, and in this book Dr. Bamford and his co-authors have presented a unified and thorough treatment of this important subject.

The two first chapters discuss the broad theoretical concepts upon which the subject rests, and the following four chapters summarize critically the experimental data for most of the important monomers and the relation of these results to the general theoretical developments. The chapter on heterogeneous polymerization—which refers only to those polymerizations in which the propagating radicals pass from one phase to another—is an original treatment based largely on the authors' own studies, and is particularly valuable since this subject is rarely dealt with in the standard works on polymer kinetics. The final chapter treats the statistical aspects of vinyl polymerizations and in particular the calculation of molecular weight distributions. This book is the most complete and up-to-date survey of the subject the reviewer has seen and it can be highly recommended to students and others interested in the synthesis of high polymers and to those chemists with wider interests in the mechanism of free radical reactions.

The book by Dr. Bovey is the first of a new series of "Polymer Reviews" (edited by Prof. H. Mark) in which emphasis will be placed on the principles and state of knowledge of newer developments in polymer chemistry, and it has set a very high standard. Although the importance of a study of the effects of radiation on dead and living matter has been recognized since the discovery of X-rays (1895) and radioactivity (1896), the greatest stimulus to the present-day intensive study of the subject has been the development of nuclear reactors and the application of high-intensity radiations. The consequent need to understand the effects of these radiations over long periods of time both on ordinary materials of construction and on living cells is obvious. In the use and application of high polymers it is clearly necessary to have a clear understanding of the mechanism of the beneficial aspects of radiation such as the improvement in mechanical properties of some plastics by cross-linking and also the scientific information which will permit the development of polymers which resist the effects of radiation. More important still may be the understanding of the effects of radiation on the polymeric material which constitutes cells and other living organisms.

This book is timely in that it reviews in a critical manner the basic results so far obtained in the study of the irradiation of high polymers. The opening chapters summarize the general properties and chemical effects of radiation and the radiation chemistry of high polymers in particular. The remaining chapters deal with the various synthetic and natural polymers in detail. The book as a whole is a thorough, critical and reliable review of this growing subject. It is a most stimulating account of the theoretical and practical aspects of what has rapidly become an important branch of polymer science.

Dr. Huggins's book is based on a course of lectures he delivered in Japanese universities and emphasizes his own important and fundamental contributions to chemistry. The book as a consequence is uneven in character. Brief reference only is made to many of the important aspects of polymer synthesis and properties whereas the valuable theoretical work of the author on the thermodynamic properties of solutions is described in detail. Other interesting chapters are those on dynamic properties of polymers and their solutions and on the general aspects of the structures of natural and synthetic high polymers. The author presents many original points of view and in this sense the book is of value to the specialist. Although covering the whole physical chemistry of polymers, the book is too condensed to be of great value to the student seeking a basic introduction to the subject. C. E. H. BAWN

MICROBES AND MILK

Dairy Microbiology

By Prof. Edwin M. Foster, Prof. F. Eugene Nelson, Prof. Marvin L. Speck, Prof. Raymond N. Doetsch, and Prof. Joseph C. Olson, Jr. Pp. xvi+492. (London: Macmillan and Co., Ltd., 1958.) 42*s*. net.

THE authors of this book are all professors or associate professors of bacteriology or dairy bacteriology in teaching institutions in the United States; this strengthens the impression, while not motivating it, that "Dairy Microbiology" is in several ways tailored to the American system of education. It is a form of students' text-book, though, as the authors hope, it should have considerable appeal in other fields, particularly technology, largely as a ready-reference book. Broadly, the first six chapters deal with the general application of microbiology to dairying, and the remaining nine with the microbiology of specific dairy products, waste disposal and the utilization of by-products. With the exception of some of the illustrations, which are lacking in clarity and definition, the quality of reproduction is admirable.

"Dairy Microbiology" is indeed a veritable omnibus and very little material that is cognate has been overlooked, but its comprehensiveness seems sometimes to have been achieved at the expense of attention to detail. The need of the student to assimilate facts while only currently developing his critical faculties evokes the responsibility of authors to present him with something approaching the bare minimum consistent with accuracy and completeness. In some places detail is lacking, while other sections of "Dairy Microbiology" are rather overloaded with data. The style and presentation of material are frequently naïve and elementary though admirably clear and straightforward, but at times assume considerable erudition on the part of the reader in disciplines other than microbiology. Despite irritating mixtures of passive and imperative tenses in descriptions of techniques, there are few inaccuracies and inconsistencies and the book cannot be criticized on matters of fact. References, with titles, are a welcome feature, even be there few to publications appearing after 1954, the book having been published in the United States late in 1957.

The subject-matter is not confined to American practice, but systems and techniques foreign to the United States receive in most cases scant mention ; there is, however, one outstanding instance where this is not so—the excellent and all-embracing chapter on the microbiology of cheese. Even here, though, the mechanization of Cheddar cheese manufacture is not covered, perhaps because of its so recent inception. There are, too, other important developments in dairy microbiology that are not mentioned, probably for the same reason, which, however good in itself, must still have the effect of dating the book : they include immersion cleaning as such, and calcium-free bacteriophage-resistant media for the propagation of starter cultures.

Perhaps the most disappointing feature of "Dairy Microbiology" is its homogeneity. Too many cooks usually spoil the broth, one imagines, by the addition of too many conflicting ingredients. In this instance, however, the authors have failed to inject into it any flavour of their own particular views or opinions, or indeed any strong flavour at all. This is particularly unfortunate since the list of individuals is indeed impressive, and many of their views are known to be both enlightened and stimulating. Although lacking any form of philosophy or impact, and leaving no profound impression other than of enormous compilation, "Dairy Microbiology" is, in that latter capacity, excellent value at so modest a price.

C. A. E. BRIGGS

APPARATUS AND APPLICATIONS OF MASS SPECTROSCOPY

Mass Spectroscopy

By Prof. Henry E. Duckworth. (Cambridge Monographs on Physics.) Pp. xvi+206. (Cambridge: At the University Press, 1958.) 35*s*. net.

THE branch of physics christened mass spectroscopy by Aston has experienced a remarkable growth. The types of instruments for ion analysis have increased in number and in performance, while their applications have extended into astronomy, biology, chemistry, engineering, geology and branches of physics other than nuclear. Prof. H. E. Duckworth has written a very concise account of the principles of positive-ion optics, the generation and detection of positive ions, and of spectrometers of all kinds used in the analysis of ions. The second half of the book summarizes the application of mass spectroscopy in physics, chemical physics and geophysics. In addition, there is briefer mention of other uses, such as gas analysis, stable isotopic tracer work and various applications in chemistry. The book concludes with a table of isotopic abundances and masses determined by mass spectrometric methods. The mass values for A less than 40 were measured by Nier and his collaborators, while greater mass values were based on the author's own research work.

The book is remarkably free from errors of a scientific kind, but some appear. Prof. Duckworth, in discussing spectrometers which provide first-order double-focusing for all masses plus second-order direction-focusing for one mass, specifically omits the common Mattauch and Herzog design of spectrometer which has the second-order focusing feature. Although some of the advantages of the vibrating-reed electrometer are specified, a most important advantage, the fact that there is no grid current, dependent on voltage, in parallel with the input current, is omitted. In discussing direction-focusing mass spectrometers with sector fields the statement is made that the resolution is independent of the angle of deflexion. This independence obtains only for symmetrical instruments. On p. 131 the (^{6}Li + n) reaction products are given incorrectly.

Almost every section of every chapter of Prof. Duckworth's monograph attributes the first study or first use of something to one or another person, and these assignments are in the main the same as those which have appeared in earlier books. There are, however, oversights and errors which might be corrected. For example (p. 13), the focusing properties of sector fields and Barber's rule were clearly illustrated by Aston in 1919. Aston (1919) also suggested focusing by a spherical condenser before Brüche and Henneberg (1935). Although Smythe, Rumbaugh and West (1934) first devised the general formula for obtaining higher-order direction-focusing in homogeneous magnetic fields, they are not mentioned in section 2·6. The emission of positive ions from heated salts and hot filaments is generally attributed to Gehrcke and Reichenheim (1906, 1907) as in section 3.2, but J. J. Thomson (1899) credits Elster and Geitel (1889) with the discovery that positive ions were emitted from hot filaments. C. J. Davisson (1912) credits the discovery of emission of positive electricity from heated salts to J. C. Beattie (1899). O. W. Richardson (1908, 1910) and his students, Hulbirt and Davisson (1912), carried out the first definitive research on identifying positive ions from hot salts and hot filaments. They thus clarified a difficult existing situation in which thermal ionization of residual gas atoms had been held responsible for the currents observed from uncoated filaments. This work, which antedated that of Dempster, is not mentioned.

Prof. Duckworth has written a concise but comprehensive book on mass spectroscopy which should prove valuable to anyone engaged in the analysis of ions. The large reference bibliography with individual page references to the text, and the index, both of which were obviously prepared with great care, enhance the value of the book.

K. T. BAINBRIDGE

Administrative Medicine

Transactions of the Fifth Conference, October 29, 30, and 31, 1956, Princeton, N.J. Edited by George S. Stevenson. Pp. 197. (New York: Josiah Macy, Jr., Foundation, 1958.) 3.75 dollars.

THE Josiah Macy, Jr., Foundation has organized more than twenty conference groups of experts in different fields during the past fifteen years, each group meeting for a few days annually over a period of five years or more. Discussions, limited to twenty-five participants, are quite informal; one member introduces a topic and is subjected to frequent interruptions by way of questions or comment. Discussions are reported verbatim in the Transactions and the interruptions too often distract the reader's attention from the main issue. There are no formal conclusions and no recommendations are made. Three topics are presented in this volume: "Mental Health Elements in Administration of General Health", by Dr. Paul V. Lemkau; "The Administrative Role in the Management of a Mental Hospital", by Dr. Alfred P. Bay; and "Co-ordination of Local Resources: Techniques and Devices for Communication and Cross-fertilization", by Dr. T. P. Rees. Discussion on all three subjects dealt mainly with the means of integrating problems of mental health with other organized medical services and securing the active co-operation of the community in this integration. This appears to be a more difficult task in the United States than in Great Britain and the description by Dr. Rees of his 'open door' policy at Warlingham Park Hospital and his organized mental health service in Croydon aroused great interest. The selection, training and qualifications of hospital superintendents were also discussed, particularly in relation to geographically isolated hospitals, hospitals closely integrated with the community and hospitals of different sizes and types. G. A. CLARK

Amphetamine Psychosis

By P. H. Connell. (Maudsley Monographs, No. 5.) Pp. 133. (London: Chapman and Hall, Ltd., 1958. Published for the Institute of Psychiatry.) 21*s.* net.

CONSIDERING the number of years that the amphetamines have been available on the market and the wide range of their therapeutic usefulness, addiction to these drugs had always been regarded as rare and limited to psychopathic personalities who might have become addicted to anything. This latest Maudsley Monograph is calculated to shake the complacency of pharmacologists, psychiatrists, medical practitioners and manufacturers, and is therefore deserving of careful study. Dr. P. H. Connell, in a study of the literature, has found only six authenticated cases of amphetamine psychosis from Britain in the past twenty years, but he goes on to report another forty-two cases, of which twenty-eight were seen by him personally and the rest were discovered by inquiry among his colleagues. He emphasizes the remarkably close resemblance between the mental symptoms of amphetamine addicts and of those with paranoid schizophrenia, and points out that a single large dose of the drug may cause psychotic symptoms. The author's tabulation of the findings in the various cases is interesting and revealing, particularly when he touches on the relationship between the psychosis and the previous personality of the patient. Unfortunately, certain parts of this book must have been written some time ago, for we are told that no fewer than seventeen patients obtained their drug supply from the contents of amphetamine inhalers. An addendum mentions that amphetamine inhalers have been withdrawn from the market.

The second part of the monograph deals with the search for, and validation and use of, a biochemical test for detecting that a patient has been taking amphetamine. There is a bibliography occupying two and a half pages. W. R. BETT

Bibliography on the Effects of Ionizing Radiations on Plants, 1896–1955

By Arnold H. Sparrow, John P. Binnington and Virginia Pond. Pp. v+222. (Upton, New York: Brookhaven National Laboratory, 1958. Obtainable from Office of Technical Services, Department of Commerce, Washington, D.C.) 2.25 dollars.

THIS list of nearly 2,600 titles is arranged alphabetically by first authors with cross-references to include others. The articles are from 496 journals, 54 of them originating in the U.S.S.R. or countries of the Eastern bloc, as well as a number of books, symposium reports, etc. There is an excellent subject index occupying 90 pages. The volume is paper bound, but printing is clear and uncrowded on heavy paper.

The usefulness of this publication will be obvious to all who have experienced the difficulty of tracking down papers dealing with the biological effects of radiation in the large number of journals through which they are scattered. Although the list may not be complete, its coverage is comprehensive enough to make it invaluable to research workers in many phases of radiation biology, botany and agriculture. It is unfortunate that at the time of release it is nearly three years out of date: a supplementary list would already be useful and will soon, in this fast-moving field, be overdue. One hopes that the success of this publication will encourage the authors to prepare a second before very long.

ALMA HOWARD

Nuclear Scattering

By K. B. Mather and Dr. P. Swan. (Cambridge Monographs on Physics.) Pp. ix+469. (Cambridge: At the University Press, 1958.) 80*s.* net.

THE authors set out to describe the physics of nuclear scattering in a volume of 469 pages, the early chapters of which provide an introduction to the relation of nuclear scattering to nuclear forces and to the kind of apparatus which is used. The main body of the book is devoted to nucleon – nucleon scattering at both low and high energies, nuclear scattering and nuclear models and resonance. In this field, in which there is so much current literature, it is not possible within the confines of a single volume to be exhaustive and up to date at the instant of publication. However, the authors do present significant results available in mid-1957 and their interpretation in terms of nuclear forces and structure. At a few places the description of apparatus appears to be too detailed. Nevertheless, the selection from the information available has been carefully made. Although to an expert in any particular aspect of nuclear scattering, the treatment may appear rather sketchy, the book as a whole is a balanced representation. For this reason it will be welcomed by experimentalists and should provide valuable reading for the graduate student starting research as well as for those already actively engaged in this field.

THE ROYAL GREENWICH OBSERVATORY

By DR. R. v. d. R. WOOLLEY, F.R.S.
Astronomer Royal

THE Yapp 36-in. reflecting telescope of the Royal Greenwich Observatory was brought into operation in September 1958. The move of the instruments from Greenwich to Herstmonceux is now therefore completed, and the Observatory can now look forward to an active observing programme with the equatorial telescopes, as well as with the meridian instruments.

There are six domes in the Equatorial Group at Herstmonceux, which contain instruments as follows. Dome *A* houses the 30-in. reflector. This telescope was formerly placed on the same mounting as a refractor, but they have now been provided with independent mountings. The telescope is available for spectroscopic or photoelectric work, and it is proposed to use it to test image-converter tubes, if these become available. The primary mirror was re-figured, but in the meantime it has been found that the secondary mirror is imperfect, and this is also being re-figured.

Dome *B* houses the Yapp 36-in. reflector. This is a comparatively modern instrument, for it was built by Grubb Parsons in 1934. It is equipped with a prism spectrograph, which is now being used to determine radial velocities of stars of special dynamical interest. It is, however, proposed to replace this prism spectrograph with a fast modern grating spectrograph, to be constructed in the Observatory's workshops.

Dome *C* at present contains the Isaac Roberts 20-in. reflector, on loan from the Science Museum, South Kensington. This small telescope is very valuable for photoelectric work, but as it is required by the Museum it will be replaced by a Schmidt reflecting telescope, for which, in fact, this dome was originally provided. It is proposed to equip the Schmidt telescope, which will have a long focal ratio, with objective prisms including Fehrenbach's double prism, with which radial velocities can be determined.

Dome *D* houses the astrographic telescope. This telescope is particularly valuable on account of the existence of old plates (some with epochs as old as 1885) taken with this and similar instruments from which proper motions can be derived by comparison between new and old plates. A programme of proper motions of stars, particularly those with special dynamical significance, is in hand. This telescope also carries the Markowitz moon camera, which is used at the time of full moon.

Dome *E* houses the Thompson 26-in. refractor. This is the telescope with which the Greenwich determinations of stellar parallax have been made. It is not generally realized that determinations of trigonometrical parallax are not really in a satisfactory state, and since so much astronomical reasoning depends ultimately on trigonometrical parallaxes, further programmes of parallax determination are of the greatest importance. It is to this work that this

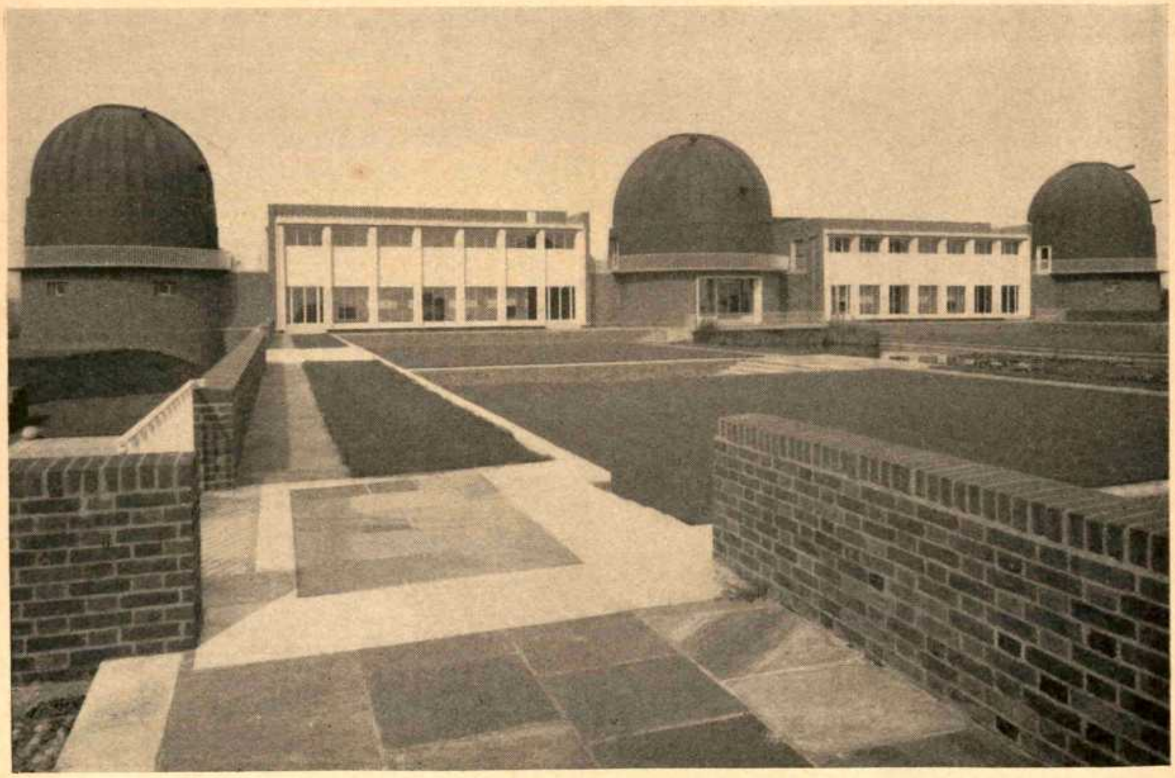


Fig. 1. The Equatorial Group at Herstmonceux

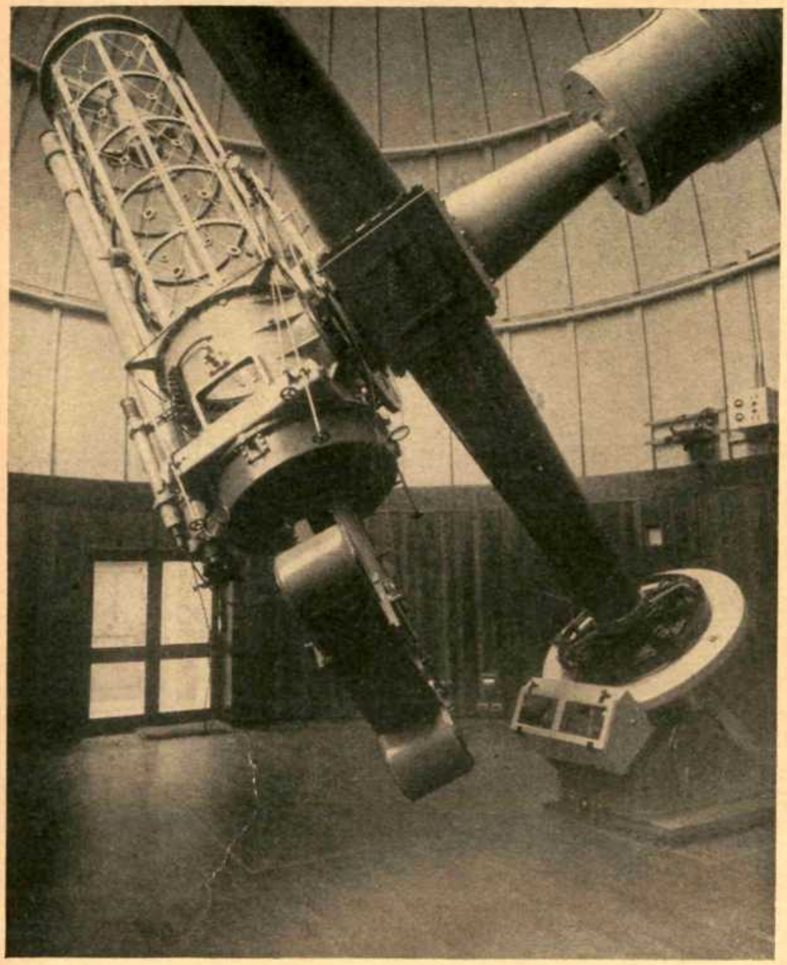


Fig. 2. The 36-in. Yapp Telescope

telescope will be mainly devoted. The dome is equipped with a rising floor.

Dome *F* contains the old 28-in. refractor. The polar axis of this telescope is in the form of an open hexagonal cage. It was designed by G. B. Airy and is a larger edition of a wooden cage which he built for the Northumberland equatorial in Cambridge. The ironwork of the 28-in. cage is one hundred years old almost exactly, but the telescope is not so old. It is larger than the original telescope and was put in the old cage at Greenwich from motives of economy. At Greenwich it could not point at the zenith because the eyepiece struck the floor as the zenith was approached. It is mounted higher at Herstmonceux and the telescope can now point at the zenith with a couple of feet to spare. It will be used for observations of visual double stars. These observations are extremely important for the determination of stellar mass. While double-star observing was prosecuted vigorously—or perhaps even overdone—at the end of the past century, not nearly enough attention is paid to the subject with large telescopes in the present decade, with the result that information which will be needed for the orbits, most of which are of long period, is not being secured.

The principal meridian instrument of the Observatory is now the Cooke Reversible Transit Circle. This instrument was constructed in 1933 and, had it not been for the Second World War, would have taken over from the famous Airy Transit Circle at Greenwich. However, detailed investigation of the instrument delayed its use on a full programme. The Airy Transit Circle remained in use until the Meridian Department moved to Herstmonceux.

Advantage has been taken of the interruption in the meridian work to introduce two major modifications to the Cooke instrument. The contact times from the transit micrometer are now recorded directly on punched cards by means of an apparatus known as *Epic* (electronic punch indicating chronograph), which has been designed and constructed in the Electronics Laboratory of the Observatory, and the visual circle-reading microscopes have been replaced by cameras. The films from the latter are measured on a screw measuring machine fitted with a digitizer, the output of which is recorded directly on punched cards. Thus, the observational data in each co-ordinate are obtained in a form most suited to automatic reduction.

The first major programme with this instrument was commenced in October 1957. This is part of the large international project for meridian observations of reference stars for the third Katalog der Astronomischen Gesellschaft, the new photographic catalogue. When compared with the second Katalog der Astronomischen Gesellschaft, this new catalogue will yield proper motions of some 200,000 stars. Twelve observatories are co-operating in this meridian programme. The Royal Greenwich Observatory has undertaken to make about 70,000 observations, including observations of reference stars, FK_3 and FK_3 Supplement stars, stars in the zones of the photographic zenith tubes, and a list of *O* and *B* type stars the proper motions of which are required for galactic research. More than 20,000 observations have been made during the first twelve months of the programme.

The Photographic Zenith Tube (P.Z.T.) was brought into operation during the latter part of 1955. The first two years observations have been analysed to give corrections to the assumed right ascensions and declinations of the stars in the 0·5°-wide zone centred on the Herstmonceux zenith.

Since the beginning of 1958, the time and latitude results have been sent regularly to the Bureau International de l'Heure in Paris, and the office of the International Latitude Service in Turin. The latitude observations are incorporated in the Service International Rapide, which was set up on the recommendation of the Dublin meeting of the International Astronomical Union in 1955 to publish co-ordinates of the pole with the minimum of delay, for use in the various national time services.

The time observations are used in the Observatory time service, and the latitude observations will be used in due course for correcting the declinations observed with the transit circle for the effect of latitude variation.

In addition to the regular determination of clock error and latitude, observations extending over a long period can be used for deriving a correction to the adopted constant of nutation.

The other new buildings at Herstmonceux house the workshop, chronometer repair shops, the Time Department with its quartz clocks, and the Nautical Almanac Office. These premises were occupied in various stages during the past year, and the move from the old huts, in which some of the departments were temporarily located, is complete. (The Time Department moved from Abinger.) The huts, which were put up in front of the Castle to provide accommodation for an insurance company that was evacuated to Herstmonceux Castle during the War, have been removed and the ground grassed over.

The control of the national time service, which had been maintained from the war-time emergency station at Abinger Common, near Dorking, was transferred to Herstmonceux during 1957. The centre block of the new West Building contains the clock cellars in the sub-basement, and the clock room, control room and battery room in the basement.

With the opportunities afforded by the transfer to new permanent premises, much care and attention were devoted to the layout, and experience so far has shown the general arrangements to be sufficiently flexible to permit modifications and development.

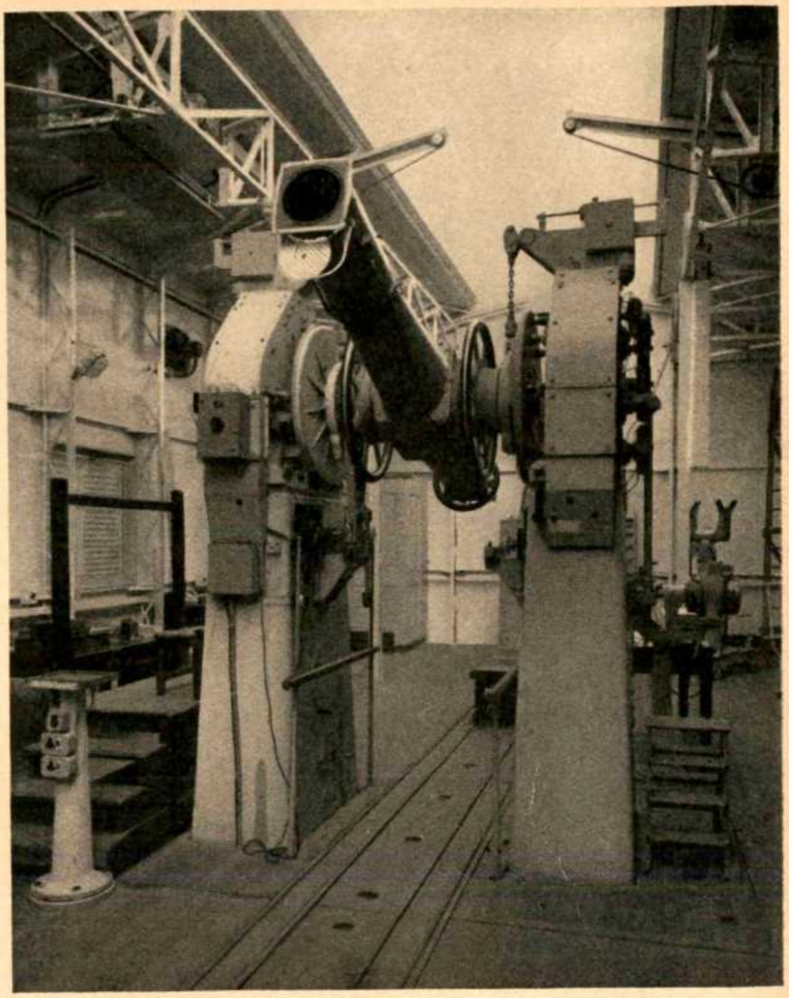


Fig. 3. The Cooke Reversible Transit Circle

The quartz clocks employ ring crystals transferred from Abinger and running in oscillators designed and made in the Electronics Laboratory. The control room equipment follows the general pattern of the Abinger installation; the decimal counter chronometers have been replaced by similar instruments of newer design; new radio receivers by Plessey and Racal have been installed in place of the war-time American receivers; in addition to single aerials on the roof of the building, a Wells array has been provided for the reception of nearby short-wave transmissions and an inclined-V array for reception of radio time signals from greater distances. A visual display unit has proved of particular value in facilitating accurate measurements on signals which have suffered distortion or which are subject to variable fading.

By means of a land-line link two standard clocks, one at the National Physical Laboratory and the other at the Post Office Laboratories, Dollis Hill, operate continuously running comparison meters at the Observatory. At any time the best clocks at the three stations may be used, in conjunction with the Photographic Zenith Tube observations, for the establishment of Greenwich Mean Time. The link with the National Physical Laboratory is of particular interest, since this permits comparison of the clocks with the cæsium standard.

Rhythmic radio time-signals, which have been controlled by the Royal Greenwich Observatory since 1927, are now regarded as obsolete and were discontinued in 1958. The 'English' type of signal, introduced by the Observatory in 1950 and still radiated twice daily, has now been generally adopted as a convenient standard. Arrangements are now in hand for the installation of control equipment at the transmitting station instead of at the Observatory, thus eliminating errors due to variations in the time of travel of the signal along the land lines.

Because of the irregularities inherent in a time-scale based on the rotation of the Earth on its axis, astronomers have adopted a new standard based on the annual period of the revolution of the Earth in its orbit around the Sun. Time determinations on the new scale are, for technical reasons, related to the motion of the Moon as observed against the background of the stars. A special Moon camera has been installed, and the Observatory has undertaken to measure plates taken at Perth, Canberra, Wellington and Naini Tal in addition to those taken at Herstmonceux.

H.M. Nautical Almanac Office has now been installed in its new offices in the West Building for more than a year. Its work largely consists of the compilation and publication of the ephemerides and almanacs required by astronomers, navigators and surveyors. In recent years there has been introduced a policy of unification of its publications with those of the Nautical Almanac Office of the U.S. Naval Observatory; for the year 1960 the astronomical ephemeris (until 1959 published under the title of "The Nautical Almanac") will be completely unified with the corresponding American publication and published under the title "The Astronomical Ephemeris".

The Office is assisting other departments of the Observatory, particularly the Meridian Department, with the calculations involved in the reduction and discussion of observations. A small electronic computing machine (the Hollerith 1201) is being installed to expand the scope for this work, for the routine calculations of the Office, and for a limited range of theoretical investigations.

The precise motion of the Moon is of foremost importance in relation to the rotation of the Earth and to the determination of Ephemeris Time. The main task of the Office is the calculation of the lunar ephemeris; and it conducts a world-wide programme of occultation prediction, with the collection, reduction and discussion of all observed lunar occultations, as a small part of this task.

Work on the Newton telescope is now to be resumed (see *Nature*, February 28, p. 579).

THE AMERICAN MINIATURE NUCLEAR GENERATOR, *SNAP III*

By W. S. EASTWOOD, L. B. MULLETT and J. L. PUTMAN

Atomic Energy Research Establishment, Harwell, Didcot, Berks

SNAP III, standing for System for Nuclear Auxiliary Power, is a miniature device capable of powering the telemetering apparatus in a space rocket. Its source of power comes from the decay energy generated by a source of radioactive polonium-210. The energy is converted directly to electric current by attaching to the polonium capsule, which heats itself to more than 700° F., a series of twenty radial thermocouple elements in the form of wheel spokes. The generator weighs 5 lb. and is $4\frac{3}{4}$ in. in diameter × $5\frac{1}{2}$ in. high. When originally charged, it held a content of 3,000 curies of polonium-210. At the demonstration at the White House some four months later, an output of 5 watts electrical power was delivered with an efficiency of 8–10 per cent.

The Martin Company of Baltimore built the device for the U.S. Atomic Energy Commission with the Minnesota Mining and Manufacturing Co., which owns patents on the thermocouples, as subcontractors. The contract was for 15,000 dollars, but the polonium source was quoted by the *New York Times* as costing 30 million dollars. Other American reports have given the basic cost of polonium as a hundred times less than this figure.

The polonium-210 is in many ways a convenient isotope to use, since it generates 5·3-MeV. alpha-particles accompanied by a low proportion of gamma-rays. The energy per disintegration is high and can be confined within the containing capsule, with small external background radiation. The whole apparatus may be handled for short times without receiving excessive radiation.

Polonium has a half-life of only 140 days, so that the useful life of this 30-million dollar battery is about four or five months. Only in a space rocket where results are paramount and weight reduction is essential can one imagine a use for such a device. Furthermore, the efficiency of the device falls off in roughly linear fashion with the difference of temperature between the hot and cold junctions, which will fall, of course, as the radiation source decays.

All alpha-emitting isotopes are a hazard, and polonium-210 is in the highest class of toxicity. In *Snap III* it is contained within two stainless steel shells and an outer one of molybdenum. Should the rocket head return to Earth, the need for three capsules will be apparent, since the maximum recommended human body-burden of radiopolonium is less than one hundred thousand millionth of the contents.

Polonium-210 is made by bombardment of bismuth with neutrons in a reactor, followed by chemical separation:

$$^{83}_{209}\mathrm{Bi} + n \rightarrow {}^{83}_{210}\mathrm{Bi} \rightarrow {}^{84}_{210}\mathrm{Po} + \beta$$

Owing to the alpha-particle hazard, all handling must be carried out in a 'dry box', and this together with the heat generated in the sample makes the compaction of 3,000 curies into a small capsule a fair technical achievement. The sealed containers are essential both for stopping the alpha-particles and to prevent diffusion of the polonium by nuclear recoil accompanying decay.

Various methods are known for conversion of atomic radiation to electricity. Direct use of the charged alpha-particles would establish a voltage in the megavolt range, which is somewhat impracticable. The electrons from a beta-active source can also be used directly to activate silicon, germanium or silicon carbide as a semi-conductor. The practical choice is at present confined to those processes using heat as an intermediary, and the most promising devices are thermionic diodes and semi-conductor thermocouples.

In a 'hard' diode, an efficiency of the order of 10–15 per cent has been obtained with a power density of 1 watt/sq. cm. of electrode by leaving very close spacing (about 0·0005 in.) between cathode and anode to reduce the space-charge effect. It is desirable to have a cathode of low work function and an anode of even lower work function for re-entry of the electrons. In principle, a diode could work with anode and cathode at the same temperature. In practice, for a diode of more reasonable geometry the space charge can be neutralized with positive ions, and much effort is being applied to the problem of introducing desirable ions such as cæsium. Any diode scheme, however, requires a temperature of the order of 1,000° C. or more.

Thermocouple devices have also been developed to similar efficiencies, but operating at lower temperatures. The old-fashioned metallic thermocouple is limited to low efficiency by excessive heat conduction, but semiconductors with poor heat transmission characteristics have revolutionized the field. The best material at present available is bismuth telluride doped with selenium and antimony to give negative and positive thermoelectric coefficients. A large number of these units can very conveniently be connected in series electrically and in parallel for heat flow. The efficiency is 5 per cent per 100 deg. C. temperature difference, but the maximum operating temperature is limited to the region of 250° C., above which the efficiency falls and the material is degraded. It is believed that an extension to 400° C. might be possible with special precautions. Lead telluride in alternate n and p type form is used in *Snap*. It has a lower efficiency for a given difference of temperature, but can be used at higher temperatures. The initial efficiency is quoted as 10 per cent, but after a half-life it falls to 5–6 per cent with an output of 3 watts. The initial power output is not directly quoted, but with 3,000 curies and 10 per cent efficiency it should be in the region of 10 watts. This would be consistent with an output after 140 days of the order of 2·5 watts, a factor of two down in power of source and a further two for reduced efficiency. There is insufficient information to determine why lead telluride was used and not bismuth telluride. It could be that bismuth telluride came a little too late, and the higher efficiency per 100 deg. C. is not a very important factor; or there might be a more cogent reason for the high temperature of the source connected with a difficulty in achieving a low temperature of the base in an artificial satellite.

Several other alpha-emitting isotopes might in theory be substituted for polonium, but it is unlikely that the natural or the trans-uranium elements would be available in sufficient quantities. The American press release suggested using the fission products Ce-^{144}Pr (half-life 285 days) having a total beta-energy of 3·3 MeV. Here the compactness of the gadget must be sacrificed. Sources of high-energy beta-rays of this activity will be accompanied by a considerable bremsstrahlung background of X-rays which would require appreciably heavy shielding.

Apart from a better and cheaper supply, no great developments can be expected from the radioactive side of these generators. The methods of conversion, on the other hand, are the subject of considerable research, and new and improved alloys can be expected to raise the temperature of conversion and the efficiency. The stimulus for this work comes, however, from the more important possibilities of direct conversion of reactor heat or waste heat to electricity.

THE INDIAN INSTITUTE OF SCIENCE, BANGALORE, INDIA

GOLDEN JUBILEE

By DR. S. BHAGAVANTAM

Director

THE Indian Institute of Science, which marked its golden jubilee by a special meeting on February 2, owes its existence to the far-sighted vision of the well-known philanthropist, the late Mr. Jamshetji Nusserwanji Tata. Unfortunately, the founder did not live to see the fruition of his idea, and it was left to his two sons, the late Sir Dorab J. Tata and the late Sir Ratan J. Tata, to carry out their father's wishes, with the active support of the late Lord Curzon, the then Governor-General of India, and Sir K. Sheshadri Iyer, who was at that time Dewan of Mysore. Mr. J. R. D. Tata, who is president of the Court of the Institute, opened the jubilee proceedings; the guests included the President of India, H.R.H. the Duke of Edinburgh and the Governor of Mysore.

The Institute may be deemed to have come into formal existence on May 27, 1909, the date of the vesting order of the Government of India. The first batch of students was, however, admitted only in 1911 with the Departments of General and Applied Chemistry and of Electrical Technology commencing to work. The Department of Organic Chemistry was added soon after. The Department of Biochemistry was opened in 1921 and that of Physics in 1933, when Sir C. V. Raman took charge as director of the Institute.

To the first director, Dr. Morris W. Travers, the distinguished chemist, and his colleagues, the Institute owes its sound foundations. Dr. Travers was succeeded by Sir A. G. Bourne (1915–21), Sir M. O. Forster (1922–33), Sir C. V. Raman (1933–37), Sir J. C. Ghosh (1939–48), who has just died (see p. 645), and Prof. M. S. Thacker (1949–55). I took charge in March 1957.

The Institute functions as an autonomous body in accordance with a scheme formulated by the Government of India under the Charitable Endowments Act. Its authorities include the President of the Republic of India as its *ex-officio* Visitor, a Court, a Council, a Finance Committee, a Board of Management for the endowed properties, a Board of Holding Trustees for the other properties, the Senate, the Faculties and the Director. The Director is the Chief Executive and Academic Officer of the Institute.

The Quinquennial Reviewing Committee, 1955, recommended that in place of the diplomas that it had been so far conferring on its students, the Institute should be enabled to confer degrees on them. On the orders of the Visitor, the Institute is now deemed to be a University under Section 3 of the University Grants Commission Act of 1956 for the purposes of that Act and is conferring the degrees of B.E., M.E., M.Sc., Ph.D. and D.Sc. instead of diplomas.

The accompanying figures (Table 1) give an idea of the Institute's expansion since its beginning.

Being in possession of well-equipped laboratories and as the leading postgraduate institution of the

Table 1

Year	Receipts (rounded to nearest thousand) Rs.	Expenditure (rounded to nearest thousand) Rs.	No. of students	No. of members of staff
1911	20,68,000	15,99,000	24	6
1919	3,24,000	3,41,000	73	7
1939	6,58,000	6,08,000	187	20
1947	32,06,000	36,67,000	221	50
1953	58,65,000	54,14,000	373	123
1958	64,05,000	66,64,000	561	157

country for advanced instruction and research in science and engineering, the Institute took up for investigation during the Second World War a large number of schemes of research sponsored by the Council of Scientific and Industrial Research, the Indian Council of Agricultural Research, the Indian Council of Medical Research and the Governments of Madras and Mysore. During that period, the Institute planned and established a Department of Aeronautical Engineering. When the War was drawing to a close, a further four-year expansion programme was launched with grants sanctioned by the Central Government. Under that programme, the Departments of Metallurgy (1945), Internal Combustion Engineering (1945), and Chemical Technology and Chemical Engineering (1951) were established; and laboratories for research in fermentation technology, food technology and pharmacology were set up. For the training of power engineers, a Department of Power Engineering was established in 1947 with laboratories for electrical, mechanical, civil and hydraulic and high-voltage engineering. A Section of Economics and Industrial Psychology, including industrial relations, and affording facilities for research in these subjects, was also started in the same year.

In 1955, under a scheme for the development of facilities for technical education, additional post-graduate courses in automobile engineering (1956), foundry engineering (1956), soil mechanics and foundation engineering (1957), electronic engineering (1956), ultra-short and microwave engineering (1956), line communication engineering and acoustical engineering were provided. Further facilities for research in technical gas reactions, physical metallurgy, hydraulic machines, internal combustion engineering, electrical measurements and measuring instruments, transmission, distribution and network practice have been added. Recently, a Department of Applied Mathematics and a Section of Industrial Engineering and Administration have been established.

The Library of the Institute is one of the best scientific and technical libraries in India.

The Institute publishes a quarterly entitled *Journal of the Indian Institute of Science*, containing original papers by the research workers of the Institute.

A noteworthy feature of the Indian Institute of Science is the objective itself with which it was founded, namely, for the provision of advanced instruction and the conduct of original investigations in all branches of knowledge that are likely to promote the material and industrial welfare of India. The broader the objective, obviously the more difficult will it be of fulfilment. However, the facts that we started with good foundations and established at a very early stage traditions of research in pure sciences like physics and chemistry, that we added later, and at appropriate times, specialized branches of technology like power engineering, metallurgy and aeronautics, and also that we did not quite neglect mathematics and even the humanities are, in my opinion, the principles that helped us to face our task and make its fulfilment come as near the ideal laid down by the founder as possible.

During the past fifty years, the Institute has grown to be one of the foremost centres of scientific research and advanced instruction in India. A large low-speed open-circuit wind tunnel of 9 ft. × 14 ft. test section was inaugurated during the recent jubilee celebrations. This tunnel is the only one of its kind in India, and will offer increased instructional and research facilities in aeroplane design. A modern a.c. network analyser, again the only one of its kind in India, has been in use for some time now in connexion with studies relating to power systems in the country. We are planning to put up and equip a modern acoustical laboratory to serve the purpose of training, research and testing in all branches of acoustics. There are many other lines of development which are not mentioned here for want of space. The Institute's contribution to the instructional aspect is reflected in the fact that more than three thousand of its alumni are now occupying positions of importance and responsibility all over the country in their fields of specialization. The research work done at the Institute has opened a new vista for generations of Indian scientists and engineers who go through its portals. Many young men and women from different parts of the country now eagerly look forward to joining the band of workers at the Institute.

The Institute is, to a high degree, autonomous in character. In the past, we confined ourselves to research and training, largely at the postgraduate level, and we propose to retain this feature in the years ahead. Thus we are able to direct our technological and scientific resources to carefully chosen specific purposes. We hope that against this background the Institute and those associated with it will have a great part to play in promoting the progress of India.

OBITUARIES

Sir J. C. Ghosh

Sir Jnan Chandra Ghosh died suddenly at the age of sixty-four at his Calcutta residence on January 21. I had been closely associated with him for some fifty years.

Sir J. C. Ghosh was a leader in physical chemistry when he was the professor and head of the Chemistry Department of the University of Dacca, which he joined in 1921, being appointed in London by Sir Philip Hartog, the first vice-chancellor of the University. He served this University loyally for twenty years and with conspicuous success as a teacher and research worker. By his devotion to science and his kindly nature, he attracted many young men and initiated them into scientific research. This seems to have been the best period in his career in the service of science and education.

In 1915 Ghosh published his first paper on the electrolysis of solutions by alternating electric current in the *Journal of the American Chemical Society*. During the First World War, Snethlage (*Z. phys. Chem.*, **90**, 1, 139; 1915) published some papers criticizing the Arrhenius electrolytic dissociation theory. I pointed out the weakness of Snethlage's views (*Medd. Nobel Inst.*, **3**, No. 15; 1916), and later developed my views in a paper to the Faraday Society, and a general discussion on the present position of the theory of ionization was organized in London by the Faraday Society on January 21, 1919. In this general discussion Ghosh's contributions to the basic conception of total ionization of electrolytes were considered and discussed and were favourably received by leading physical chemists of Britain, and papers by him were published in the *Journal of the Chemical Society*, London. However, other physical chemists scrutinized the conceptions and arguments of Ghosh and pointed out that they were not valid. Although Sutherland (*Phil. Mag.*, **3**, 161; 1902; **12**, 1; 1906) and Milner (*ibid.*, **25**, 742; 1913) introduced the conception of complete ionization, Ghosh's papers were mainly responsible for the development of this idea and its applications by Debye and Hückel in their theory of strong electrolytes. Later, Ghosh and his collaborators published some interesting papers on catalytic gaseous reactions and photochemistry, which have been followed up elsewhere.

During the Second World War, Ghosh was appointed director of the Indian Institute of Science, Bangalore, which expanded in various directions during his regime. In this period he was knighted, chiefly for his war services.

When Dr. Shyama Prosad Mukherji was appointed Minister in the Union Government, he took Ghosh to Delhi to assist in the expansion of technology in India. After a short stay in Delhi, he was sent to be the first director of the Indian Technological Institute at Kharagpur, West Bengal. Then he was appointed the first whole-time vice-chancellor of the University of Calcutta; but he had to give up this post after a short time on his appointment as a member of the Planning Commission for Science and Technology in India.

Lady Ghosh, three sons and two daughters survive him.

N. R. Dhar

Prof. W. Riddet

Prof. William Riddet, director of the Dairy Research Institute (N.Z.) at Palmerston North, New Zealand, died on December 30 at the age of sixty-two.

Prof. Riddet was born of farming parents in Ayrshire, Scotland. He graduated B.Sc. and N.D.A., N.D.D. (with honours) at the West of Scotland Agricultural College and the University of Glasgow. In 1921 he joined the staff of the West of Scotland Agricultural College, first as dairy instructor and later as lecturer. In 1925 he migrated to New Zealand to take up the then recently established Logan Campbell chair of agriculture at Auckland University College. In co-operation with Prof. G. S. (now Sir Geoffrey) Peren, then Walter Buchanan professor of agriculture at Victoria University College, Wellington, he organized the establishment, in 1927, of Massey Agricultural College, at Palmerston North, to which both professorships were transferred. At about the same time he played a leading part in the arrangements for the development of the Dairy Research Institute (N.Z.), an organization set up under the ægis of the N.Z. Department of Scientific and Industrial Research to undertake scientific research work as a service to the rapidly expanding dairy products manufacturing industry. Prof. Riddet was appointed the first director of this Institute.

Thus it was in the dual role of dean of dairying (and later vice-principal) of Massey Agricultural College and director of the Dairy Research Institute (N.Z.) that Prof. Riddet made his outstanding contribution to the advancement of dairy science and dairy practice, and thereby to the general welfare and prosperity of his adopted country.

Prof. Riddet had from the outset that very important attribute of a leader in teaching and research, an original and ranging mind. His interests covered a wide field; and wherever his interest lay his mind was active in devising and fostering ideas for investigation and research. Endowed with what seemed to be an inexhaustible reserve of energy, he devoted himself to his duties with an astonishing persistency.

As a teacher he set for his students very exacting standards. The value of his teaching is shown in the calibre of the men who came under his influence—they are to be found occupying positions of high responsibility in New Zealand, in Great Britain, and in many other countries. His spirit lives in the training and inspiration he has passed on to these students.

It lives, too, in the organization which he controlled from its beginnings, the Dairy Research Institute (N.Z.). Under his guidance the Institute has gained an international reputation for its work on a number of aspects of dairying practice. While the publications describing this work do not often carry his name as author or co-author, all those who have worked under him will readily acknowledge their debt to him. With typical generosity he made no claims, and passed on his ideas without reservation. It was for him sufficient recompense that he could see the work being done and the Institute serving well the industry from which it drew its support.

The impact of Riddet's personality on the teaching of agricultural science, and on the dairy farming and dairy products manufacturing industry in New Zealand, will be evident for many years to come.

F. H. McDowall

Mr. F. W. James

On January 27, Mr. Francis Wogan James, librarian to the Imperial College of Science and Technology, London, died after years of illness most bravely and cheerfully borne.

From Haverfordwest he went to the Royal College of Science as a Royal Scholar in 1930, and after taking his degree in 1933 he became a research student in inorganic chemistry. During 1936–38 he was research assistant to the professor of highway engineering in the Department of Civil Engineering of the City and Guilds College—a transfer from one to another of the constituent parts of the Imperial College which made it easy for him, in later years, to take a broad view of the needs of the whole College.

In 1938 'Frank' James asked the Dean of the City and Guilds College for permission to apply for the post of College librarian—an appointment which, academically and financially, was junior to the one he was holding—in order to be in a better position to contribute to science and learning by providing his colleagues and the students of the College with books and periodicals. How right he was the members of the College soon realized: although he never obtained a formal qualification in librarianship, he possessed a fine sense of the essentials of library service and a great love of books, and in the past twenty years the library has expanded in size much faster than the College itself and its value to the readers grew from year to year.

His work at the City and Guilds College was interrupted by war service, during 1941–46, in the Army. His work there was mainly concerned with motor transport and with radar, and his bent for these branches of engineering remained in clear evidence when he returned to his College on demobilization.

Frank James loved books, but he took an even greater interest in his readers. He knew hundreds of students by name and the subjects on which they were working, and—being a scientist himself—knew the importance of acquainting them, as soon as a journal arrived, with papers in their fields of interest. Several new lines of research at the College were stimulated by his understanding of papers on similar subjects appearing in what seemed unlikely journals. In addition, he was, when asked, ready to offer his help in the design of apparatus and showed a fine understanding of the construction and use of chemical and electronic equipment.

He possessed great charm and modesty and no member of the College had a greater fund of kindness. Students from overseas were especially grateful to him, for he could sense the needs of shy and lonely people and give them comfort for which they, in turn, gave him their devotion. Frank James will be sadly missed by countless friends who will long remember the kindness received from him and his charming wife. In 1958 he was appointed to be librarian in charge of all libraries at the Imperial College, and it is the College's good fortune that his spirit is alive in his staff.

P. O. WOLF

Dr. Marcel Ballay

DR. MARCEL BALLAY, president and managing director of the Centre d'Information du Nickel, Paris, died on February 2 after a short illness.

Born in 1896, Marcel Ballay entered early upon a career in metallurgy in the laboratory of the de Dion plant, of which he was afterwards appointed head, in 1925. In 1928 he joined the Centre d'Information du Nickel, first as technical manager, becoming later vice-president and in 1954 succeeding M. Jean Dhavernas as president. In 1955 he was appointed an officer of the Legion of Honour in recognition of his services to industry and to the teaching profession. He was a member of many learned societies in France and Great Britain. Under his direction the services offered to industry by the Centre d'Information du Nickel increased in importance, and it is as the head of that office and as a leading and respected metallurgist that Dr. Ballay will be remembered both in France and Great Britain.

NEWS and VIEWS

Airborne Radar at the Royal Radar Establishment: Dr. T. S. England

DR. T. S. ENGLAND, who has been promoted to deputy chief scientific officer and appointed head of the Airborne Radar Department at the Royal Radar Establishment, Malvern, graduated from the University of Durham with first-class honours in physics in 1937 and remained at Durham to undertake research on the heating effects of ultra-short radio waves in dipole solutions. At the outbreak of the Second World War in 1939, he joined the Air Ministry Research Establishment (later the Telecommunications Research Establishment) and worked primarily on the design of radar transmitters, initially at metric and later at centimetre wave-lengths, becoming head of the Transmitter Design Group in 1944. He was given leave of absence from Malvern during 1948–50 to take up a research fellowship in medical physics at the University of Durham, when he applied his extensive knowledge of electronics to studies of the effects of microwave radiations on living tissues and of microwave resonance phenomena in paramagnetic solids and liquids. He was awarded a Ph.D. for his thesis on these researches. On return to the Telecommunications Research Establishment, Dr. England was for a time responsible for research techniques in the millimetre band before being appointed a superintendent of the Radar Ballistics Division at the Royal Radar Establishment in 1956.

Defence Research Policy Staff: Mr. R. V. Whelpton

MR. R. V. WHELPTON, who has been promoted to deputy chief scientific officer and appointed Ministry of Supply representative on the Defence Research Policy Staff at the Ministry of Defence, took his M.Sc. at the University of Sheffield in 1938. After graduating in physics, he spent the next eight years with the research department of the Metropolitan-Vickers Electrical Company, where he worked on high-voltage research and on the development of the high-speed cathode-ray oscillograph. He was also engaged on investigations of transient phenomena in switchgear and the development of the electron microscope. In 1936 he joined Sir Robert Watson-Watt's original team on research and development of ground radar at Orfordness and Bawdsey. This work in 1940 was transferred to the Royal Aircraft Establishment at Farnborough, where Mr. Whelpton was also concerned with other aspects of radio research and development. In 1949 he continued on the same work with the Directorate of Electronics Research and Development at headquarters of the Ministry of Supply. In 1955 he was appointed scientific adviser on air defence to Supreme Headquarters Allied Powers in Europe (SHAPE) and was a member of the study group which led to the formation of the SHAPE Air Defence Technical Centre (SADTC) in The Hague. While at The Hague, as senior British representative, Mr. Whelpton pioneered efforts to enable SADTC to promote integrated air defence for Nato. Mr. Whelpton is a Fellow of the Institute of Physics and he has published a number of papers, two of which have been awarded premiums by the Institution of Electrical Engineers.

Ministry of Supply: Mr. J. H. Phillips

MR. J. H. PHILLIPS has been promoted to deputy chief scientific officer and appointed to the headquarters post of director of Guided Weapons (Techniques). In this post he will be responsible for directing research and development on guidance and control techniques, advanced engineering techniques specially applicable to guided weapons and on propulsion. His career as a scientist has been almost entirely in the Government service. After taking an honours degree in physics at the University of London in 1937, Mr. Phillips worked throughout the Second World War on radio and radar problems, first at Bawdsey Manor and later at the Telecommunications Research Establishments at Swanage and Malvern. This was followed by a two-year term as guided weapons liaison officer in the British Supply Mission (now British Joint Services Mission) in Washington. Moving then to the Royal Aircraft Establishment, Farnborough, he worked for four years in the Guided Weapons Department at the most formative period of this new activity. Thence he was transferred to the headquarters staff of the Ministry of Supply on similar work, and for the past two years has been serving as head of the guided weapons group in the British Joint Services Mission, Washington.

Communication Principles at the Bell Telephone Laboratories: Prof. J. W. Tukey

PROF. J. W. TUKEY, professor of mathematics at Princeton University and a member of the mathematical research department of the Bell Telephone Laboratories, has been appointed assistant director of research in communications principles at those Laboratories. Prof. Tukey will continue to occupy the chair of mathematics at Princeton, a post he has held since 1950.

A native of New Bedford, Massachusetts, Prof. Tukey graduated in chemistry from Brown University in 1936 and was awarded the degree of Ph.D. by Princeton University in 1939. He joined the technical staff of the Bell Laboratories in 1945. His work has covered development of new statistical techniques; broad analysis and synthesis problems related to complex weapons systems; and other problems with mathematical or statistical aspects. He was a Jacobus Fellow at Princeton in 1938–39, a Fellow of the John Simon Guggenheim Memorial Foundation in 1949–50, and a Fellow at the Center for Advanced Study in the Behavioral Sciences in 1957–58. Prof. Tukey is a member of the Division of Mathematics of the National Research Council and serves on several of the Council's committees, including the Committee on Atmospheric Sciences and the Committee on Behavioral Sciences. He has also served on a number of advisory committees to the United States Government, frequently in connexion with military problems.

Zoology at University College, Canberra: Prof. J. D. Smyth

THE news of Prof. J. D. Smyth's appointment to the chair of zoology in the newly established Science Faculty in University College, Canberra, has been received with mixed feeling by Irish zoologists. A Dublin man and a graduate of the University of Dublin, he has spent the greater part of his academic life in his Alma Mater. In 1948, he returned to Dublin when he was made a Fellow of Trinity College and lecturer in zoology. In 1954, he became a professor of experimental zoology. Prior to his return to Dublin, Dr. Smyth held appointments in the Universities of Leicester and Leeds. Prof. Smyth is known to physiologists and parasitologists alike through his research on the physiology of tapeworms. This work chiefly concerns the culturing of the Pseudophyllidae *in vitro*. His technique permits the aseptic removal of the plerocercoid larvæ from the body cavity of fish and their cultivation in various media. By raising the temperature to 40° C., he induced the plerocercoid to mature and reproduce. One interesting result of his work indicates that development, as far as oviposition, depends on some bacterial by-product in the medium. Work on *Ligula intestinalis* has yielded fertile eggs which hatched into normal coracidia, proving a much-debated point that the tapeworm is self-fertile. Using a similar technique, Smyth also succeeded in showing that *Schistocephalis solidus* produced *in vitro* eggs capable of up to 85 per cent embryonation. Dublin has just conferred the degree of Sc.D. on Prof. Smyth—a fitting distinction and well earned. To him, his wife (Mildred Moore, also a graduate in zoology of the University of Dublin) and his two sons, his friends wish many happy years in the country of their adoption.

H. J. Hamburger (1859–1924)

THE distinguished Dutch physiological chemist, Hartog Jakob Hamburger, was born at Alkmaar a century ago on March 9, 1859. He studied chemistry at the University of Utrecht and, after obtaining his doctorate in science, served for seven years as assistant in physiological chemistry to Franz Cornelis Donders. Having graduated M.D., he became lecturer in physiology and pathology at the Utrecht Veterinary School in 1888, and in 1901 he was elected to the chair of physiology at Groningen, where ten years later he was responsible for creating a magnificent new institute. He was president of the International Physiological Congress held at Groningen in September 1913 on the occasion of the twenty-fifth anniversary of its foundation.

A skilled designer of ingenious and deceptively simple experiments and a tolerant and kindly man, Hamburger is remembered eponymously for his 'phenomenon' (the chloride shift); his 'interchange', also called 'secondary buffering'; and his 'law', which states that, when blood is rendered acid, albumins and phosphates pass from the red blood corpuscles to the serum and the chlorides pass from the serum to the cells, and that the reverse occurs when the blood is rendered alkaline. As early as 1867 Nathan Zuntz had suggested that carbon dioxide is carried in the plasma by virtue of some substance present in the red blood corpuscles. It was Hamburger who furnished the final proof of this theory. Hamburger's best-known book is entitled "Osmotischer Druck und Ionenlehre in den medizinischen Wissenschaften" (three vols., Wiesbaden, 1902–4). He also contributed to our knowledge of calcium ions in phagocytosis and of næmolysis. A member of the Royal Academy of Amsterdam and recipient of many honorary degrees, Hamburger died at Groningen on January 4, 1924, aged sixty-five.

Peaceful Uses of Outer Space

Mr. R. Allan, Under-Secretary of State for Foreign Affairs, stated in a written answer in the House of Commons on February 24 that last December the General Assembly of the United Nations set up an *ad hoc* Committee to study the question of international co-operation in the peaceful uses of outer space under United Nations auspices. The Committee, which is composed of eighteen member States, including the United Kingdom, the United States of America and the Soviet Union, is to consider the co-ordination of national research programmes. So far, the Soviet, Polish and Czechoslovak delegates have refused to participate in the work of this Committee, but Mr. Allan hoped that they will reconsider their decision.

Research on Road Accidents

In a written reply to a question in the House of Commons on February 25 as to the steps being taken to increase research on the prevention of road accidents, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that extensive researches with this objective generally were being carried out by the Road Research Laboratory. This covered such problems as the control of vehicles during emergency braking, improvements in tyres and road surfaces to give better adhesion on wet roads, improvements in vehicle and street lighting, and in helmets for motor-cyclists. Safety aspects of motor-vehicle design to minimize injuries in road accidents were being investigated in the Slough area in co-operation with the police and the Medical Research Council. The staff available for this detailed study had recently been increased, and facilities for simulating accidents and testing individual components were being built up. Full co-operation existed, and the Laboratory studied research results obtained in the United States and elsewhere with a view of their application here. In 15 per cent of accidents studied in 1955–58 a mechanical defect in the vehicles had played an important part and about half the defects were in the brakes.

Chapelcross Nuclear Power Station

At the United Kingdom Atomic Energy Authority's nuclear power station at Chapelcross, near Annan, Dumfriesshire, the first of the four reactors, which became critical last November, has now been taken in service for the generation of electricity. The Chapelcross station, which will have a generating capacity of 184,000 kW. and will, when all four reactors are completed, feed about 140,000 kW. to the national grid, has been built by the United Kingdom Atomic Energy Authority as a dual-purpose station to provide plutonium and electricity. Another nuclear power station is being built by the South of Scotland Electricity Board at Hunterston in Ayrshire for the provision of electricity and will supply 320,000 kW. of power to the grid. The construction of Chapelcross is under the control of Messrs. Merz and McLellan, acting as agents for the Atomic Energy Authority's Industrial Group; this is the first occasion on which a private firm has been employed in this way in Britain on a major project. The official opening of the Chapelcross Station, by Sir John Crabbe, Lord Lieutenant of Dumfriesshire, will be on May 2, when it will be open to the public.

New Oceanographical Ship for Woods Hole

The sea-going fleet of the Woods Hole Oceanographic Institution, Massachusetts, was recently increased to five ships by the addition of the 92-ft. auxiliary ketch *Aries*, to do scientific work around Bermuda under Dr. John Swallow. Purchase of the ship was made possible with funds made available for the purpose by Mr. Richard J. Reynolds, of Sapelo Island, Georgia. *Aries* will be used mostly to study sub-surface ocean currents with the aid of Dr. Swallow's neutrally buoyant floats, which were used last year in the discovery of a counter-current under the Gulf Stream and in studying the outflow of Mediterranean water through the Straits of Gibraltar in the co-operative effort of the British National Institute of Oceanography and the Woods Hole Oceanographic Institution during the recent International Geophysical Year.

Built in 1953 of teakwood over steel frames, at the Camper and Nicholson Yard in Gosport, *Aries* was designed for world-wide cruising and is well appointed. Aft there is generous room for nine, and her forecastle has room for six. The ship is 70 ft. long on the water line, and has a beam of 19½ ft. and a draught of 12 ft. *Aries* is equipped with a 100-h.p. AEC Diesel engine capable of driving the ship at 8 knots and has a fuel capacity for 2,000 miles. Built to Lloyd's highest specifications, the vessel has copper sheathing on the bottom. The ship will remain under the command of her captain, John W. Gates; the Woods Hole Oceanographic Institution will operate her with a crew of eight. The fleet of the Woods Hole Oceanographic Institution also includes the 213-ft. *Chain*, the 142-ft. *Atlantis*, the 125-ft. *Crawford* and the 110-ft. *Bear*. Two small vessels, *Asterias* and *Risk*, are used for inshore work.

College Biology Courses on Television

The Fund for Advancement of Education established by the Ford Foundation has awarded Station *KETC-TV* and Saint Louis University a grant of 58,300 dollars to cover the academic costs for the production of a film series entitled "Principles of Genetics". The series of forty-five films, to be financed by the McGraw-Hill Co. of New York, are scheduled to be shown over *KETC-TV* network initially in the spring semester of 1960 and will serve as the basis for a regular college credit course in genetics. Simultaneous with the initial showing in Saint Louis, the films will be available to all colleges, universities, hospitals and industries throughout the world. Prof. John D. Dwyer, director of the Department of Biology, and Dr. Irwin H. Herskowitz, associate professor of biology in Saint Louis University, will serve as special consultants in the organization of scientific data for the series of films. The subject-matter will be recorded on film by leading specialists in the field of heredity, and is the first television series in biology, given by a number of leading scientists, of the Educational Television Station's plan for a College of the Air.

Brachiosaurus Exhibit at the Smithsonian Institution

The Smithsonian Institution has recently placed on exhibit in the Dinosaur Hall of its Natural History Building at Washington one of the largest dinosaur limb bones ever known. It is the humerus (upper arm bone) of the sauropod dinosaur, *Brachiosaurus altithorax*, and it was discovered by D. E. Jones of Delta, Colo., who presented it to the Smithsonian. Geologically speaking, it is from the Morrison formation, of late Jurassic age (about 130 million years ago), in Montrose County, Colo. The bone is 6 ft. 10 in. long. *Brachiosaurus* was a giant among dinosaurs, much larger than the familiar *Brontosaurus*; it may have weighed as much as 55 tons. It is distinguished from other dinosaurs by the fact that its front legs were somewhat longer than its hind legs. This feature, the great length of the neck, and the projecting nostrils on top of the head seem to have been adaptations to its presumed habits. *Brachiosaurus* was a plant-eater that walked along the bottoms of lakes, lifting its head above the surface of the water to breathe. *Brachiosaurus* is known from North America, Africa and Europe.

Ethnographic Films

THE Ethnographic Film Committee of Great Britain and Ireland presented three films at the National Film Theatre on March 1. Prof. C. von Fürer-Haimendorf, who has recently returned from nine months field work in a Sherpa village on the Nepal–Tibet border, presented a colour film showing the Sherpas at work in their fields and with their yaks. It also showed a Buddhist festival in a monastery headed by a reincarnate lama. David Attenborough went to New Guinea as a zoologist in search of birds of paradise. He and his cameraman, Charles Lagus, filmed courtship and wedding ceremonies of some of the highland tribes. The film also showed the native method of manufacturing salt and of making the stone axes which are now largely used for ceremonial and prestige purposes. The Iban dyaks of Sarawak were formerly renowned as head-hunters, and head-hunting ritual still plays an important part in their lives. Hugh Gibb, with the co-operation of Tom Harrisson, curator of the Sarawak Museum, made a colour film showing their slash-and-burn method of cultivating rice, tattooing, weaving, and many aspects of domestic life in the long houses in which entire communities live, each family in its separate apartment.

The Ethnographic Film Committee of Great Britain and Ireland is a committee of the Royal Anthropological Institute. It was established as the national committee in 1958 by the Joint Committee for Anthropological Research and Teaching, to co-operate with the national ethnographic film committees of other countries. In addition to sponsoring film programmes for teaching and public presentation, the Committee is preparing a catalogue of ethnographic films available in the United Kingdom.

Department of Scientific and Industrial Research Grants for Students

UNDER its second five-year plan, the Department of Scientific and Industrial Research proposes to increase substantially the number of its postgraduate studentships and fellowships in science and technology. By 1963–64 expenditure on this scheme is expected to exceed £1·5 million and the postgraduate students supported to number 3,800 in place of the present nearly 1,900. Grants for special research projects at universities and colleges under the Department's scheme, including provision for research in the human sciences in relation to industrial needs, are expected to increase three- to four-fold, to about £1·75 million in 1963–64. The latest issue of "Notes on D.S.I.R. Grants for Graduate Students and Research Workers" (pp. 28. London: H.M. Stationery Office, 1959. 1*s*. 9*d*. net) gives full details of the regulations governing such awards, with an appendix on awards tenable abroad. The rates for the latter, while varying from country to country, will be equivalent to those received by a student or a Fellow in Britain, and in addition, second-class rail fare and travel subsistence will be paid. Research fellowships vary between £700 and £850 a year and are normally held for two years. Under the studentship scheme, approved fees are paid to the appropriate authority and the maintenance grant paid to the student varies from £420 a year to students living in college, hostel or lodgings at Oxford and Cambridge, £400 at London and £340 elsewhere, to £285 to students living with parents in London and £270 to students living with parents elsewhere.

International Association for the Exchange of Students

THE report for the year ended September 1958 of the International Association for the Exchange of Students for Technical Experience is accompanied by a survey of the first ten years of the Association in Great Britain during 1948–57. In the summer vacation of 1958, 776 students went abroad and 829 students were received; forty-two universities and colleges are now affiliated and twenty-four countries participate, Of the 4,968 students sent abroad from Great Britain under the Association in 1948–57, nearly a third (1,504) were from the Imperial College of Science and Technology; 272 were from the University of Durham, 263 from Birmingham, 220 from Bristol, 238 from Manchester, 228 from Cambridge, 186 from Glasgow, 180 from University College, London, and 173 from the University of Leeds. In 1958 it became necessary to restrict the nomination of students to those completing the penultimate year on an undergraduate course who had already had some previous industrial experience in Britain. Stress is laid on the contribution by British industry, and an evaluation of the exchange based on information from reports on 4,269 students indicates the undoubted success of the scheme. With scarcely any exception, the students proved genuinely anxious to work hard and gain the maximum benefit, but the vital necessity of great care in selecting students for the exchange is stressed.

Grants for Study Overseas

THE British Council handbook entitled "Scholarships Abroad, 1959–60" (pp. iii + 27. London: British Council, 1959), to which the director-general, Sir Paul Sinker, contributes a foreword, lists by country awards offered by foreign governments and universities to enable British students to continue their studies abroad. Mostly they are offered annually, and the handbook includes particulars of conditions, value, duration and fares as well as of method of application and the closing date for receipt of applications.

Toxicology and Applied Pharmacology

AFTER the recent appearance of a new British pharmacological journal, *Biochemical Pharmacology*, it comes as somewhat of a shock that a new toxicological journal has been published in the United States. For each individual scientist it becomes increasingly difficult to keep up with the literature, and the immediate reaction to any new item on the list of journals is one of resentment. However, it is true that, as the editors of *Toxicology and Applied Pharmacology* point out, an increasing number of toxicological investigations are carried out in industry, government departments and universities, and that it would help the workers in toxicology to have the investigations collected in a single journal rather than scattered in many periodicals. It may, in fact, relieve pressure on the space available in the existing pharmacological journals if some of the toxicological material need no longer be published there. The new journal will only publish papers written in English, and the first issue consists of papers by authors from the North American continent. The editorial board, however, includes non-American members, so that contributions by authors from other continents will obviously be welcome. The first issue of *Toxicology and Applied Pharmacology* (1, No. 1; January 1959. Pp. iv + 1–118. Published bi-monthly. Annual subscription, 13 dollars or 93*s*. New York and London: Academic Press, Inc., 1959) contains eleven papers, mostly on toxicity tests in animals. It is well produced, but it may be regretted by some readers that the summaries of the papers are in small print, since they are the most widely read part of a journal.

Report of the Imperial College of Science and Technology, London, for 1958

The fifty-first annual report of the Governing Body of the Imperial College of Science and Technology, London, for the year ended July 31, 1958, records a further increase in the number of students. Full-time undergraduate students numbered 1,589 and postgraduate students 848, increases of 74 and 148, respectively, on the previous year, while part-time students (nearly all postgraduates) increased from 324 to 674. The teaching staff increased from 353 to 380, bringing the total of professors and readers to 36 and 62, respectively. The growing importance of nuclear technology was marked by the appointment of a reader in nuclear technology in the Department of Chemical Engineering, and the work done in the study of automatic control systems in the Department of Electrical Engineering is being extended to take account of the needs of other departments. At the end of the session the College's proposals for a new residential block to house nearly 400 students and provide refectory and common-room space for larger numbers was approved. Besides the statement of accounts, departmental notes and lists of publications, appendixes to the report include lists of special lectures, details of staff changes and Sir Alexander Fleck's address on Commemoration Day in October 1957.

Digitizers and other Equipment for Data Processing

Data processing schemes are generally required to handle information which is originally in analogue form, that is to say, the signal takes the form of a continuous variable. For transmitting this information it is convenient to quantize it into discrete steps and then to transmit it in digital form. A descriptive catalogue published by Hilger and Watts, Ltd., London, and entitled "Digitizers and other Equipment for Data Processing", describes the principles of operation, and gives full technical information concerning a number of analogue – digital converters or digitizers, mainly of the type in which an input shaft drives a coded disk. Both mechanical and optical read-off systems are available. Details are also given of various ancillary equipment, including numerical displays, amplifiers and a typewriter for printing values of measured variables.

Scientific Careers in the Ministry of Supply

Under the title "An Invitation to Science Graduates", the Ministry of Supply and Central Office of Information have issued a booklet describing scientific careers open in the Ministry of Supply, copies of which are being sent to honours graduates in science as they qualify in British universities over the next two or three years. Besides indicating the nature of the careers, conditions of service, opportunities for promotion, the booklet gives particulars of how to apply.

Biological Effects of Space Flight

The United States National Academy of Sciences–National Research Council has set up an Armed Forces–National Research Council Committee on Bio-Astronautics to advise the Armed Forces on matters concerning the biological or medical aspects of space exploration. The following scientists—representing different fields of endeavour in universities, private research organizations, and the Armed Forces—have been appointed to the Executive Council: *Chairman*, Dr. Otto H. Schmitt (Department of Physics, University of Minnesota); *Vice-Chairman*, Dr. Melvin Calvin (Department of Chemistry, University of California, Berkeley); *Members*, Dr. Howard J. Curtis (Department of Biology, Brookhaven National Laboratory), Dr. Paul M. Fitts (Department of Psychology, University of Michigan), Brig.-Gen. Don D. Flickinger (Directorate of Life Sciences, Air Research and Development Command), Dr. John D. French (Department of Anatomy, University of California Medical Center, Los Angeles), Capt. Charles F. Gell (Office of Naval Research), Dr. James D. Hardy (U.S. Naval Air Development Center, Johnsville, Pa.), and Col. Robert H. Holmes (Research and Development Command, Office of the Surgeon General, Department of the Army). Administrative responsibility for the Committee has been vested in the National Research Council's Division of Medical Sciences, under the chairmanship of Dr. R. Keith Cannan. The other members of the Committee are Dr. Sam F. Seeley (secretary) and Major Kay Cutler, of Air Research and Development Command. The full Committee on Bio-Astronautics —which will consist of more than a hundred members, of whom at least half will be nominees of the Armed Forces—will meet periodically to review scientific and technical problems, exchange information, and establish liaison between investigators with allied interests. It will concern itself with any field of science or of technology bearing upon bio-astronautics, including pertinent aspects of astronautics, biology, chemistry, medicine, physiology, psychology, and related interdisciplinary sciences.

The Association of Consulting Scientists

The Association of Consulting Scientists has recently been formed, to act as a clearing bureau for inquiries for independent scientific services. Membership of the Association embraces independent wholetime consulting scientists in the United Kingdom in all fields of science and technology other than medicine and civil, mechanical and electrical engineering. The founding members are mostly chemists and biologists, but physics and other sciences are expected to be represented soon. The new Association will operate in close collaboration with the Royal Institute of Chemistry and other professional institutes, and with organizations concerned with the co-ordination of British efforts in research, production and marketing. The following officers of the Association have been elected: *Chairman*, Dr. J. G. Davis; *Hon. Treasurer*, Dr. G. W. Ferguson; *Hon. Secretary*, W. H. Stevens, to whom inquiries can be addressed at 15 Hawthorne Road, Bromley, Kent.

The Leopoldina German Academy of Sciences: Elections

THE Deutsche Akademie der Naturforscher Leopoldina, Halle, recently elected the following new members, in the sections indicated: *Anatomy*, Prof. Stefan Krompecher (Debrecen, Hungary), Prof. Dietrich Starck (Frankfurt am Main), Prof. Friedrich Wassermann (Lemont, Illinois), Prof. Wolfgang Bargmann (Kiel); *Surgery*, Prof. Willi Felix (Berlin), Prof. Karl Vosschulte (Giessen), Prof. Rudolf Zenker (Munich), Prof. Heinrich Kuntzen (Jena), Prof. Egbert Schwarz (Erfurt); *Zoology*, Prof. Manfred Gersch (Jena); *Mathematics*, Prof. Heinz Hopf (Zurich), Prof. O.-H. Keller (Halle); *History of Science and Medicine*, Prof. Pedro Lain Entralgo (Madrid), Prof. N. A. Figurovskij (Moscow), Prof. P. A. Juschkewitsch (Moscow); *Chemistry*, Prof. Josef Anton Goubeau (Stuttgart); *Botany*, Prof. Bohumil Němec (Prague); *Physiological Chemistry*, Prof. John T. Edsall (Cambridge, Mass.); *Odontology*, Prof. Wilhelm Meyer (Göttingen); *General Biology*, Prof. Eduard Kellenberger (Geneva).

"Some Palæomagnetic Investigations on Chinese Rocks"

DR. A. E. M. NAIRNS has written in connexion with this communication in *Nature* of January 24, p. 254, stating that the present Fig. 1 is incorrect; the plotted points are mirror images of the actual points. On the original tracing, the graduations were drawn on one side of the sheet and the experimental points were, unfortunately, inserted on the other side; in preparing the block, the tracing was photographed from the wrong side.

Announcements

PROF. I. N. SNEDDON, professor of mathematics in the University of Glasgow, has been awarded the Makdougall-Brisbane Prize for 1956–58 of the Royal Society of Edinburgh for his work on thermal stresses published in the *Proceedings* of the Society within the period of the award.

THE Institution of Electrical Engineers is organizing an International Convention on Transistors and Associated Semiconductor Devices, which will be held at Earls Court, London, during May 21–27, together with an exhibition of scientific instruments employing such devices. Further information can be obtained from the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

THE second conference on Liquid Fuels, organized by the Institute of Fuel, is to be held at the Palace Hotel, Torquay, during May 11–14, when twenty-one papers will be presented. Enrolment forms are available from the Secretary, Institute of Fuel, 18 Devonshire Street, London, W.1, from whom further information can be obtained.

A JOINT meeting of the British Radio Frequency Spectroscopy Group and the Groupement AMPERE will be held in the Physics Department, Queen Mary College (University of London), Mile End Road, London, E.1, during April 1–3 on "The Study of Molecular and Atomic Motions in Solids and Liquids by Radiofrequency Methods". Further information can be obtained from Dr. J. G. Powles at the address given above.

THE Conference of the Oil and Colour Chemists' Association will be held in Edinburgh during May 5–9. The technical sessions, under the general title "A Survey of Polymers", will be held in the North British Hotel under the chairmanship of Prof. E. L. Hirst. Registration forms and further information can be obtained from the general secretary, R. H. Hamblin, Oil and Colour Chemists' Association, Memorial Hall, Farringdon Street, Holborn, London, E.C.4.

A CONFERENCE on Industrial Prospects in Nuclear Energy is being organized by the European Nuclear Energy Agency of the Organization for European Economic Co-operation. The conference, sponsored by the industrial federations of member and associated countries, and by the Council of European Industrial Federations, is to be held in Stresa, Italy, during May 11–14. Further information can be obtained from the European Nuclear Energy Agency, 38 Boulevard Suchet, Paris 16e.

A JOINT meeting of the AGARD Aeromedical and Flight Test Techniques and Instrumentation Panels will be held in Athens during May 11–15. The subject of survival and the reactions of the pilot to unforeseen hazards will be discussed. Special papers will be presented on: escape and survival techniques; medical and human engineering aspects of flight in non-conventional aircraft; and psychopathological stress problems in flying personnel, considered exclusively with reference to research required, or data obtained from research already carried out. Further information can be obtained from the Advisory Group for Aeronautical Research and Development, Organisation du Traité de l'Atlantique Nord, Palais de Chaillot, Paris 16°.

A JOINT symposium on Instrumentation and Computation in Process Development and Plant Design, organized by the Institution of Chemical Engineers, the Society of Instrument Technology and the British Computer Society under the ægis of the British Conference on Automation and Computation, is to be held at the Central Hall, Westminster, during May 11–13. Sessions will be devoted to improving the efficiency of existing processes; the design of new processes; the application of on-line computers; recent developments in instruments, on-line computers and computers for design; and the use of computer techniques in large and small companies. Preprints of the proceedings will be available; attendance is open to members of the sponsoring bodies and non-members on payment of a registration fee. Further details can be obtained from the General Secretary, Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

NEW CANADIAN FIRE RESEARCH LABORATORY

By R. F. LEGGET

Director, Division of Building Research, National Research Council of Canada

FIRE research in Canada advanced significantly with the opening on October 3 of the new Fire Research Laboratory of the National Research Council of Canada at Ottawa. The new building forms part of the Building Research Centre of the Council's Division of Building Research. It is situated on the extensive property of the Council known as the Montreal Road Laboratories, an area of about 400 acres in which the three engineering research divisions of the National Research Council and some other Council establishments are situated.

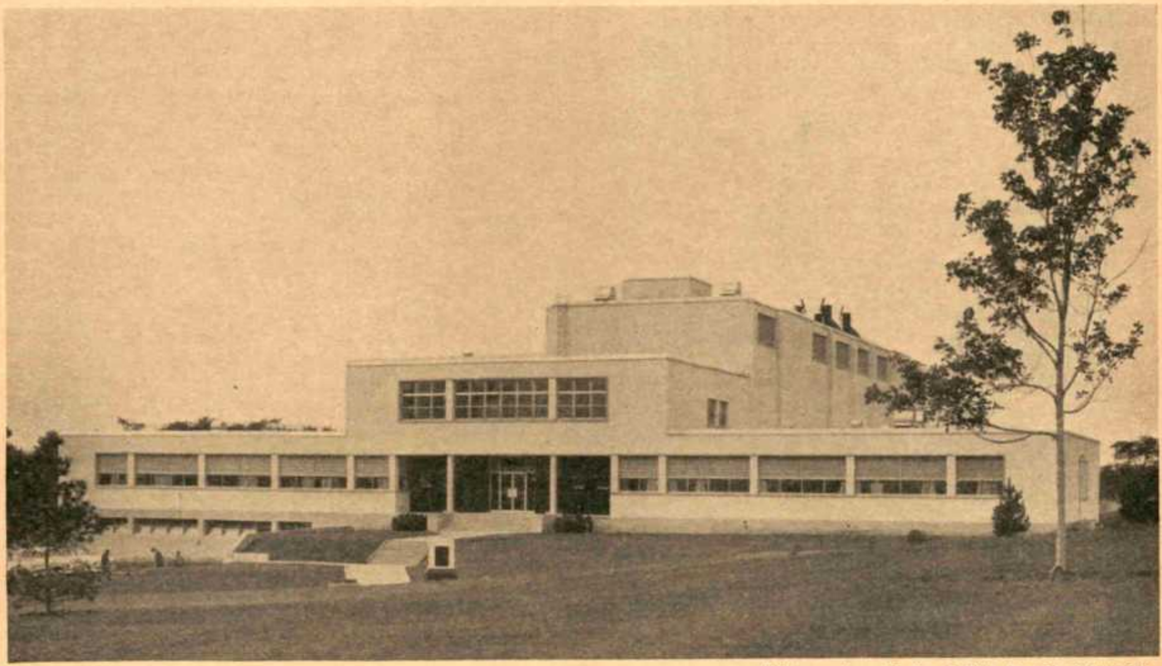
The official opening of the building was performed by Dr. F. M. Lea, director of the British Building Research Station, assisted by Mr. Dennis Lawson, the newly appointed director of the British Joint Fire Research Organization, both of whom had come to Ottawa especially for the occasion. The Canadian Division of Building Research has close liaison with both these British research organizations, the debt to which in the development of its work and in the planning of the new building was acknowledged by the director during the opening ceremony.

The opening of the new building followed a two-day conference on fire research and fire prevention, at which statements were presented regarding the work of all the major fire-prevention agencies of Canada. Speakers from the United States, Britain and Canada gave a review of fire research throughout the world. Some details of Canadian fire research were given to the conference, including preliminary results from full-scale burns of eight buildings in the small town of Aultsville, abandoned because of flooding caused by the construction of the international power dam on the St. Lawrence.

The fire research building (Fig. 1) has basically the shape of a large T, with offices and laboratories in the front wing, and the large furnace laboratory and a burn area for model studies in the rear wing. One-story additions have been erected on either side of the furnace laboratory to provide storage and workshop facilities, garage space for the station wagon used in field investigations, a control room for the operation of the fire-resistance furnaces, and additional laboratory facilities for hydraulic testing.

The building covers an area of 20,000 sq. ft. and has a total volume of more than 550,000 cu. ft., of which nearly half is made up of the volume of the 40-ft. high structure housing the furnace laboratory and the burn area. The total contract price, including all extras, which amounted to less than 4 per cent of the original cost, was 820,000 dollars, or a cost per cubic foot of less than 1.50 dollars.

The building, founded throughout on solid rock, consists of a structural steel frame supported on reinforced concrete. The outside walls, built of structural clay tile, are finished with stucco on metal lath on the outside and with glazed tile on the inside.



(*Photograph: National Film Board of Canada*)

Fig. 1. Fire Research Building of the Division of Building Research, National Research Council, Ottawa

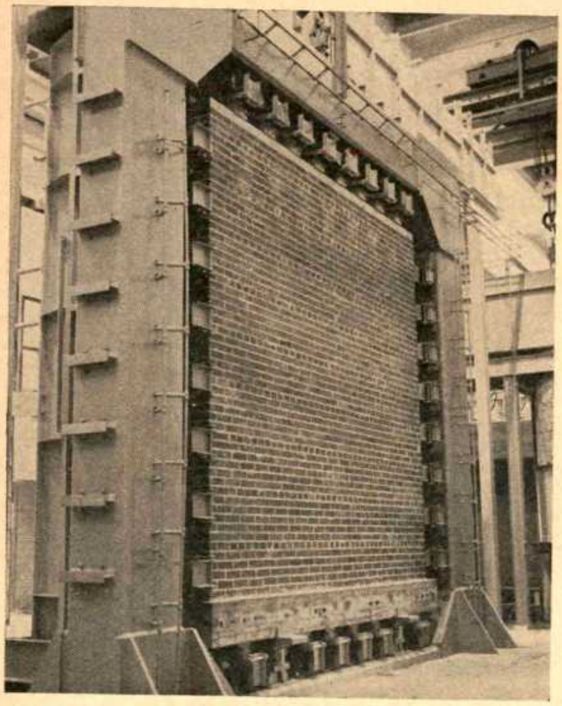
The area to the rear of the Fire Research Building was the site of an old quarry. Its rocky floor, which is approximately 5–10 ft. below the level of the surrounding area, provides an excellent outdoor experimental site on which to conduct large-scale tests on extinguishing fires.

The fire-resistance test facilities consist of two furnaces, complete with auxiliary equipment, together with the associated facilities for constructing, handling, conditioning and disposing of large test specimens. The design of the special facilities contained in the laboratory was carried out concurrently with the design and construction of the building itself, by a separate firm of consultants, Ewbank and Partners (Canada), Ltd., working in co-operation with the architects and engineers for the building.

The wall furnace (Fig. 2) consists essentially of a movable burner assembly open at the front, with the burners situated in the rear wall of the unit. The combustion chamber is completed when the front face of the burner assembly is fixed to the specimen under test. In this position the top of the furnace is immediately under the flue used for removing the combustion gases.

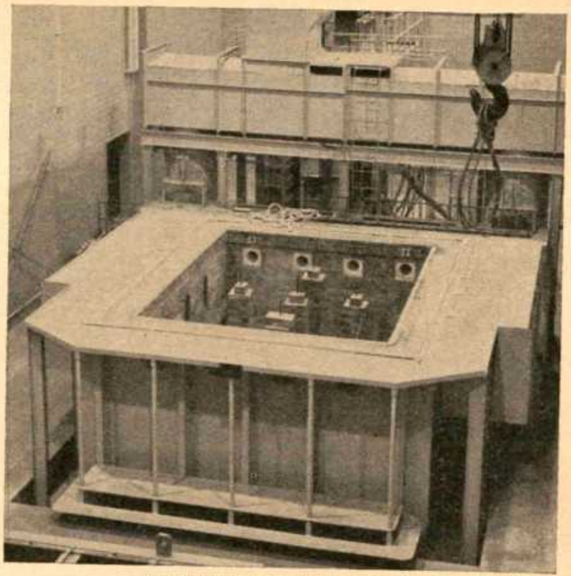
The size of the specimen exposed to the combustion chamber is 12 ft. by 12 ft., although the loading frame itself will accommodate a specimen 14 ft. by 14 ft. The heat in the combustion chamber is supplied by 100 burners having a capacity of 50 cu. ft. of gas per hour at a pressure of 25 lb./in.^{2}. The fuel used is propane, having a gross heating value of approximately 2,500 B.T.U./cu. ft.; thus the maximum total heat input is approximately 12,500,000 B.T.U./hr.

The floor furnace (Fig. 3), in contrast to the wall furnace, is a fixed installation. The burners are installed in the two long sides and the two flues are permanently connected to the common flue used for conducting the flue gases from the building. The combustion chamber is completed when the specimen is laid on top of the furnace.



(*Photograph: National Film Board of Canada*)

Fig. 2. Loading frame with wall specimen in wall furnace in the furnace laboratory



(*Photograph: National Film Board of Canada*)

Fig. 3. Floor furnace in the furnace laboratory

The furnace at present will allow a floor specimen to have an area of 12 ft. by 15 ft. exposed to heat. When using this furnace for testing beams it will be possible to extend a beam past the furnace wall and load this portion of the beam as well.

Heat is supplied by means of thirty burners (fifteen on each side), each burner having a capacity of 220 cu. ft. of gas per hour at a pressure of 25 lb./in.^{2}. As in the case of the wall furnace, propane will be the fuel, so that the gross heat input is approximately 16,500,000 B.T.U./hr.

Liquid propane is stored in a 1,750-gallon tank situated outside the building. When operating the furnaces, the liquid is passed through three vaporizers, each capable of vaporizing 70 gallons of propane per hour at 25 lb./in.^{2}. The gas is then piped underground in a 4-in. pipe to the building. Inside the building the propane then passes through a diaphragm motor control valve, which closes if there is a failure of the control air. There is a pilot flame by-pass valve in the line before the motor control valve, and two shut-off gas cocks immediately after this valve direct the flow either to the floor or to the wall furnace. The wall furnace has ten banks of burners with ten burners in each bank, while the floor furnace has five banks of three burners each on each side. Each group of three burners is fitted with a solenoid-actuated shut-off valve and pressure gauge.

The combustion control for both of the furnaces is furnished by a potentiometric temperature-programme controller which follows the time – temperature curve designated in the current U.S. Standard (ASTM *E*119-57, Standard Methods of Fire Tests of Building Construction and Materials).

The two large furnaces will be put to use immediately for carrying out tests upon the fire-resistance of building materials in current use in Canada. These tests must be done since the furnaces are unique in Canada, but they involve an element of research, and the furnaces will be used for research investigations whenever possible. In the laboratories, studies will continue on the properties of foam as an extinguisher of fire, into the problems of radiation from fire and on more detailed questions such as those related to the burning characteristics of materials. The results of all work will be made available to the committees responsible for the National Building Code of Canada for incorporation into successive revisions. The Code is an advisory document published by the National Research Council of Canada, and has legal effect only when adopted by municipalities for their own local use. It is already in legal use in this way for well over one-third of the population of Canada. As its adoption spreads, the results of the fire research programme will therefore be of direct effect to a large proportion of the people of the Dominion.

CHANGING INDUSTRY

THERE are clear signs that the post-war period of steady expansion is coming to an end. European competition is increasing, and there is a formidable growth of productive capacity in every continent. Apparent over-capacity in industry, the coming of nuclear power, international shortage of capital and low raw material prices are all contributing to a readjustment of the world's economy and are posing a direct challenge to British management.

This was the theme of the national conference of the British Institute of Management which was held at Brighton during November 26–28, 1958. The variety of papers presented by many distinguished speakers gave the hundreds of delegates considerable choice of meetings to attend; this is one of the admirable features of the Institute's conference which commends it to so many members but also makes it impossible to describe adequately. In two days there were twenty-three separate meetings and at least twenty-five study groups at which the topics ranged from staff assessment and grading to the best use of scientists in industry, the balance between technological education and management education and the problems of accounting in large multi-unit undertakings.

In the opening address Sir Harold Howitt, one of the three members of the Council on Prices, Productivity and Incomes, emphasized that the chief challenge facing management is inflation. So-called creeping inflation with its cumulative effects may soon become galloping inflation and get out of hand. But it is no use paying lip service to the desirability of killing inflation unless one is prepared to take the medicine that is involved in the process. Nor is it any use putting all the blame for inflation on one or other section of the community or expecting it to take all the medicine. All must exercise restraint. Wage increases are not harmful if they keep within the increase in productivity, since prices can then remain stable and the increase in wages will have been real. In the industrial field as a whole, total profits after depreciation from 1950 to 1956 have been about one-third as much as wages and salaries; profits must bear their share of responsibility for inflation.

One of the most important contributions to the conference was made by Griffith Page, managing director of the National Union of Manufacturers Advisory Service, Ltd., who described the ways in which small firms were being helped towards greater efficiency. Five years ago the Union was set up as a department of the National Union of Manufacturers, with financial aid under the Conditional Aid Scheme, and with emphasis on management and production organization. The lines along which the service developed were decided by the nature of the problems presented by the firms who sought its aid, by conviction that efforts and resources should be directed towards making the maximum possible impact in terms of productivity and efficiency upon the general population of small firms, and by the necessity to make the service self-supporting.

The natural interest of the membership of the National Union of Manufacturers and occasional Press reports have been adequate to generate a flow of inquiries, the follow-up of which has kept a growing staff fully engaged.

Altogether, some five hundred firms, representative of a wide cross-section of the smaller firms, have used the service, and the Union's Advisory Service has been able to acquire an increasingly intimate understanding of the financial pattern, the management structure, the production organization and the problems of small firms. Although the promotion of work study as a principal agency for promoting higher productivity held, and does still hold, an important place among the objectives of the Advisory Service, it was necessary to take a wider view of the management problems in small firms. This led to the adoption of a survey technique which approximates to the American concept of the management audit. Such surveys involve an appraisal of the overall business position of a company, its industrial standing, its policy and objectives, financial position, management structure, sales organization and productive efficiency. Their purpose is to enable the National Union of Manufacturers Advisory Service, Ltd., to indicate in what directions companies can most beneficially take action to improve their prosperity and well-being.

After such a survey, recommendations are made, and these may cover any one or a number of areas of management responsibility. The firm may be advised to install one or other of the principal management techniques, of which work study is predominant, because it usually provides the necessary foundation for others, like production control and standard costing. The introduction of work study is one which requires an appreciable period of full-time assistance, and the Advisory Service staff of industrial engineers is available to shoulder the main responsibility for its introduction and to train members of the firm's own staff so that the schemes introduced shall be properly maintained. The Advisory Service seeks to assess the limitations and the potentialities of the smaller firms in the total business sense, to explain how sound principles of management and modern techniques of management can be applied in the context of their own highly individual situations, to indicate the advantages which can flow from their adoption and, in so far as it is necessary to ensure that this is adequately accomplished, by helping them either on a part-time or full-time basis over a period.

In a thoughtful and stimulating paper concerned with the challenge of change in export markets, Mr. B. H. Dyson, sometime director and general manager of Hoover Overseas Production, Ltd., emphasized that, although many people think that Britain's troubles stem from trade unions, shop stewards, restrictive practices, cradle-to-grave social services, or nationalized industries, the restrictive outlook and practices of management could be more dangerous. The most dangerous factor in Britain to-day is acceptance of the lowering of the standard of expectancy. How can one expect a higher standard of living and yet apply less physical, mental and spiritual effort towards its attainment ? The challenge of the change calls us to create the attitude of mind conducive to arousing the desire of achievement. One factor which can actively contribute to the conversion of high wages into low costs and competitively priced products into a higher standard of living is the continuous and progressive rise in both management and worker productivity. Future success will depend almost entirely on directors and management having the courage to accept change ; products of superior styling and design ; manufacturing at competitive costs, consistent quality and realistic delivery ; good salesmanship and adequate service.

To-day with many directors and managers the home market takes precedence over export markets simply because the home market is familiar to them and its requirements fully understood. With export markets the profit margins are smaller, adding further to the temptation to rely on the more assured and less exacting demands of the home market. Only too frequently a company will take infinite trouble to appoint a representative to look after the Birmingham market, but will be content to appoint an agent (without even having seen him) to look after a whole country abroad.

The only way to explore the possibilities of business overseas is by personal visits to gain knowledge of the country itself, of the sort of competition which exists there, of the sales methods which will work most successfully, and of the field covered by other foreign competitors as well as by the nationals.

If the extent of the business potential does not warrant setting up an overseas company, the appointed representative should know details of the company's expectations, prices, terms of payment, stocks, service, advertising samples, methods of handling competitive merchandise, commission, profits, deliveries, expenses, literature and price lists.

Not enough training is being given for the export market. Not enough engineers from the countries now developing towards an individual economy are being offered postgraduate training with British engineering firms, while British sales and technical engineers going overseas for their companies are not being given the necessary additional training in the customs and language of the overseas countries to enable them to present British industry at its best.

Often in overseas markets a typical British design is not acceptable, and the overseas customer cannot always be sold the idea that the British home market is the acme of good design. Full-sized British egg-cups are not suitable for the small-size Indian and Asiatic egg, and lawn mowers built for the trim lawns of Britain are useless for Australia, New Zealand and uneven coarse grass. In India it is said that British motor-cars are recognized by a 2-in width of adhesive placed around the edges of the windows to keep out the monsoon rains. Style and colour are selling features, and here the product must be a fashion leader and not a fashion follower.

The design office and drawing-board are the cradle and kindergarten of production costs. If the design of the product and each individual component is not efficient from a functional or accepted standard point of view, no matter how perfect the manufacturing may be, the cost of production will be high. A factory in France is manufacturing 17,000 coffee mills a day that are sold all over the world at between 30*s*. and £2 each, and no competitor has been able to approach the value. A manufacturer of electric frying pans tooled up for 3,000 per week and has not been able to maintain 300 per week, because good as the value may be, the average housewife regards a frying pan as a 10*s*. 6*d*. article. An article which sells well at 1*s*. may not sell in a larger size at 1*s*. 6*d*. even if better value is represented by the larger size.

Research into the problem of designing for low-cost production is an important step towards enhancing sales. The main object should be to direct research into : (1) the reduction of the number of component parts ; (2) the reduction in the number of production operations ; (3) minimizing metal removal operations and the standardization of detail.

Efficient utilization of material demands a change of outlook on manufacturing costs. Often considerable time, ingenuity and expense are involved in designing and making machines and tooling aimed at reducing the direct labour cost by 10 per cent. A 10 per cent saving on direct material would show a much greater cost saving. Investigations into this aspect of cost reduction have indicated that often one must consider not only the value of the material in the product, but also the ratio of material utilization to the original material purchased. The design specification can assist production by : (1) reducing to a minimum the variety of finishes ; (2) standardizing chemical or plated finishes that assist the economics of mechanizing the finishing processes ; (3) commoning-up and standardizing on the undercoats for enamel finishes ; (4) arranging that the variety of finish coats can be baked at a consistent time and temperature so as to aid the mechanization of dip, spray, electrostatic and baking operations to a conveyorized process.

Considerable attention must also be given to ensure consistent quality standards from machining operations. Often the production engineer neglects to define in the process operation sheet the inspection operations, stating in detail the dimensions and points which need to be checked. To 'motion study' a production operation and ignore the workplace and equipment supplied to inspection viewers is paying lip service to the important job of maintaining consistent quality at controlled prices.

Nothing is more disappointing to a customer than transit damage, whether it be frost-bitten fruit trees, scratched furniture, a chipped surface plate or an out-of-line machine tool. Correct packing is essential and can be costly. Special containers and crates to assist transportation may be necessary. Shipping space and conditions have to be considered ; under the water-line stowage may need extra protection.

In the American and Canadian market, especially, the styling and presentation value of the package is very important as a sales feature. The product may have a "good old English reputation"; but the pack must be cleverly styled so that the old tradition is presented in conformity with the currently accepted mode.

The method to be used in marketing a product in a specific country is a top-level decision. If the potential market is large enough it is invariably best to establish a subsidiary company. It is certainly more satisfactory to appoint an importing house to act as agent or a company to handle the sole distribution rights than to accept orders from all and sundry.

One of the most unusual management training centres in Europe was described by Clark E. Myers and F. A. Kirby. The school was set up at Lausanne in September 1957 by the Nestlé Alimentana Co., and is designed to provide a nine-months course in business administration for middle management executives from all over the world. The staff consists of American professors recognized in their fields for teaching, publication, consulting and research who wish to continue working in an environment which closely resembles an academic situation.

During the first two years, executives have attended the course from companies in Australia, Belgium, Brazil, Canada, Chile, Cuba, Denmark, Egypt, England, France, Germany, Greece, Holland, Italy, Mexico, Puerto Rico, Malaya, South Africa, Spain, Sweden, Switzerland and the United States. Patterned after the middle-management programme of the Harvard Graduate School of Business Administration, the programme is designed primarily for men whose average age is about thirty-five and who fall within the age range of 30–40.

Based on the Harvard experience, from which background nearly all the professors are drawn, the case method is used almost exclusively. The major exceptions are several weeks of the programme where the elements of accounting and statistics are taught. The policy is based on the belief that experienced men can achieve a greater sense of stimulation, motivation and involvement by dealing with actual business situations.

One-third of the course is devoted to the quantitative data areas of control and finance (which includes such work as statistics, accounting, index numbers, budgeting and data processing); one-third to distribution (including retailing, marketing, sales management and international trade); one-sixth to production, factory management, general management and business policy; and one-sixth to human relations, personnel and labour problems.

The professors teach on three consecutive days either at the beginning or end of the week. The remainder of their time is devoted to writing new teaching materials better suited to an international school. In their employment agreements with the Institut pour l'Etude des Methodes de Direction de l'Enterprise they have agreed to forgo all consulting activities and devote full time to teaching, writing and research for the Institute.

The professors are assisted by research associates. These men have nearly all studied or worked in the United States, and among them have knowledge of nearly every European language. They travel with the professors and assist in research and the writing of new teaching notes and case problems.

Through the development of these materials and cases, the professors gain additional insight into European business affairs, provide better class-room data for the participating executives, assist in publicizing the school and stimulate the interest of European executives in business research and education.

During the first year about two hundred 'pieces of work' were produced. These included new cases, translated cases, technical notes, and a major study of food distribution in seven European countries.

With the increased emphasis on international business, with the coming impact of the Common Market and the free trade area, the directing staff of the Institut pour l'Etude des Methodes de Direction de l'Enterprise believes that such an institution with an international outlook is both desirable and necessary.

Of the many other papers, two of the most outstanding were forecasting and controlling the return on capital involved by J. A. Scott, chief financial executive of Hayeshaw, Ltd., and the effect on quality of administration on technical and commercial efficiency by A. C. Durie, general manager (administration) of Shell-Mex and B.P., Ltd.

TURBIDITY CURRENTS

It was thought for many years that the sediments on the floor of the deep ocean were laid down slowly, the rate of deposition being of the order of millimetres a century. Extensive coring has shown, however, that there are many layers of sand, some with shallow-water fauna, interbedded with the normal deep-water clays and oozes. Turbidity currents, in which a relatively thin layer of sediment-laden water flows rapidly down-slope, have been suggested as a possible mechanism. These currents could deposit such layers of sand in a matter of hours.

When first introduced rather more than twenty-five years ago, the notion of turbidity currents was received sceptically; since then large velocities have been postulated, but it is difficult to imagine their being produced by such contrasts in density on such gentle slopes. Nevertheless, the idea is now generally accepted by marine geologists, or at least it would appear so from the discussion of the subject held at the Royal Astronomical Society on November 28. Dr. G. E. R. Deacon acted as chairman.

The evidence supporting the turbidity-current hypothesis was reviewed by Dr. A. S. Laughton. He pointed out that sediment-laden underflows are well known in lakes, being particularly well documented in the case of Lake Mead. It has been estimated that, of the two million tons of sediment deposited in Lake Mead during 1935–48, an appreciable fraction was deposited by turbidity currents extending along the whole length of the lake. The flows are slow, consistent with the slight contrast in density and the gentle slope, but retain their identity for more than a hundred miles.

The classical case of a turbidity current in the ocean is that produced by the Grand Banks earthquake of 1929 which, by breaking a succession of telegraph cables over a period of 14 hours, provided estimates of the velocities reached. These decreased from almost 30 m./sec. to about 6 m./sec. as the slope decreased from about 1 in 100 to 1 in 1,000. It seems that this rapid and highly turbulent flow traversed some 1,000 km. and had a breadth of some 300 km. For some geologists these are unimaginably high velocities on this scale, but Heezen and Ewing, who suggested the turbidity-current explanation, have much to support their view. Not only were several of the cables later found to be buried so deeply as to be irrecoverable, but two cores which Heezen later obtained in the area both had thick sand layers of shallow water origin overlying the normal deep sea deposits.

Turbidity currents in lakes and in the ocean were linked by the laboratory investigation of Keunen, who produced similar flows on a small scale by the sudden release of fluid mixtures of water, clay and sand. The important result was that a simple hydraulic formula was found to apply, implying that the effect of the overlying fluid could be neglected, as could the acceleration in the flow. Turbidity currents in lakes, ocean and laboratory were not inconsistent with the simplest formula used to describe river flow. Using this formula, Keunen estimated the depth of the Grand Banks turbidity current to vary between 270 m. and 120 m. during its passage.

Dr. R. Stoneley, in discussing the suggestion that the breakages of submarine telegraph cables, following the Grand Banks earthquake of November 18, 1929, occurred through the passage of a turbidity current, remarked that the hypothesis has the merit of being more free from *ad hoc* assumptions than some of the other explanations proposed. The idea deserves further examination from the hydrodynamical point of view. In particular, two aspects have to be considered, namely: (*a*) whether the turbidity current would spread longitudinally too greatly to be effective; (*b*) whether the motion of the current would persist over distances of the order of 1,000 km. without being damped out by viscous forces.

Under (*a*), the longitudinal spread of the mass of water charged with sediment has much in common with the problems of the surge following the breaking of a dam and of the subsidence of a column of water, considered respectively by R. F. Dressler, and by W. G. Penney and C. K. Thornhill. A rough calculation based on the work of these authors suggested that the depth of the current as envisaged by Kuenen would be much too great; the hypothesis would be more workable if the current had a thickness of only a few metres. Question (*b*) depends on the viscous drag of a stream at high Reynolds numbers; the theoretical and experimental work of G. H. Keulegan on arrested saline wedges suggests a much lower drag coefficient than is appropriate for lower speeds. Keulegan's experiments show that the logarithm of the drag coefficient depends linearly on the logarithm of the Reynolds number, and an extrapolation of this result indicates a thinner turbidity current, with a vertical thickness of about 5 metres. Such a thickness would help to meet the difficulty mentioned under (*a*).

Further investigations of these hydrodynamical problems are very desirable, and examination is needed of the effectiveness of such a current in transporting and sorting sediments to the degree required.

Two points relating to Dr. Stoneley's contribution were made in the subsequent discussion. It was pointed out that in laboratory experiments the down-slope turbulent flow of a fluid under a less dense fluid leads to the formation of a somewhat bulbous 'nose' which travels only a little slower than the body of the fluid. The speed of the 'nose' is considerably less than the long-wave velocity in a perfect fluid. An adequate theory is not yet available. It was also remarked that the diminution of the drag of the sea-bed with increasing Reynolds number may be unjustified if the bottom is hydrodynamically rough. Observations show no decrease of drag coefficient with increasing velocity in the high Reynolds numbers (greater than 10^7) of tidal streams.

Dr. T. H. Ellison based his contribution on the work he is doing in collaboration with Dr. J. S. Turner. Their investigation concerns the ventilation of coal mines, but is applicable to the many situations in Nature in which a thin layer of turbulent fluid flows between a boundary and a relatively quiescent underlying or overlying fluid of different density. These include katabatic winds in the atmosphere and what appear to be katabatic bottom-currents in the ocean, as well as the many complicated phenomena observed in estuaries. Turbidity currents are a special case in which the turbulent fluid is made heavier by suspended solids. Some dust storms in the atmosphere are probably similar phenomena.

In the case of turbidity currents it seems that a relatively simple hydraulic theory would describe the observations if the friction and mixing with the overlying fluid could be neglected. It is therefore necessary to make some estimate of the amount of the non-turbulent fluid which would be entrained into the gradually thickening layer of turbulent fluid flowing beneath it. The rate of flow into the lower layer can be expressed as EV, where V is a typical velocity of the lower layer. E is the so-called 'entrainment constant', and if the two layers had the same density, $E \simeq 0{\cdot}08$. In this case the interaction of the two fluids could by no means be neglected. However, E decreases as the hydrostatic stability increases and it is reasonable to assume that E is a function only of the Richardson number, Ri, which is a dimensionless measure of the stability given in this case by $Ri \equiv (\rho - \rho_0)\, gh/\rho V^2$, where g is the acceleration of gravity, ρ, ρ_0 are the densities of the lower and upper fluids, and h is the depth of the lower fluid. Two sets of experiments have been made to determine E in relation to Ri. The results are scattered but agree that for $Ri > 0{\cdot}8$, which is the case in turbidity currents, then E becomes very small. The interaction between the two fluids is much reduced by the strong hydrostatic stability, and it is for this reason that a turbidity current can retain its identity for a long period and that the flow can be described by a simple formula applicable to river flow. Ellison's results are therefore broadly similar to those based on Keunen's work and support his conclusion: turbidity currents are compatible with our present knowledge of turbulence in stratified fluids.

The discussion which followed showed almost complete acceptance of this point of view; those against the turbidity-current hypothesis were either absent or silent. This is not to say that no problems remain. We know little of the ways in which turbidity currents are started or of the factors which determine whether water laden with sediment will behave as a heavy fluid or as a sloppy sort of solid. How often do turbidity currents happen? Were they stronger and more frequent during Ice Ages, and could they then have cut submarine canyons?

They presumably happen so infrequently that they make no contribution to the economy of the bottom water. For the same reason there is little hope of direct observation, although bathyscaphists report that they have started mudslides when landing on steep slopes. Attempts to start them by using explosives in canyons have had little success. Altogether, considering its potential importance in the formation of abyssal plains and the structure of some sedimentary rocks, the turbidity-currents hypothesis seems to have had little influence on marine geologists. It is surprising, for example, that following the classical Grand Banks turbidity current only two cores have been collected from the area—and they apparently during borrowed time from a cruise with other objectives. Both these cores, taken some 20 km. apart, have sand layers at the surface. Below this, each has further layers of sand, but there is so little correlation between them that one can only speculate as to the horizontal structure. Taking closely spaced cores is technically difficult, time-consuming and expensive, but in some areas the expense would surely be justified.

H. CHARNOCK

THE BRITISH COUNCIL

REPORT FOR 1957–58

THE annual report of the British Council for 1957–58* includes a general survey of the year and is preceded by an article on the printed word by Sir Charles Snow, which stresses the importance of the work the Council is doing in this field on an expenditure of only £17,000, but urges the need for expansion. The report is accompanied by a separate account of the Council's work for visitors and students from overseas. More than half the report is occupied by appendixes listing the officers, executive committee, advisory committees and panels, with their membership, and giving particulars of university interchanges, courses and study tours, etc., arranged by the Council in the United Kingdom or overseas, exhibitions and publications, and an analysis of the estimates and accounts.

The increase in the Government grant for 1957–58 to £3,378,271 out of gross expenditure of £3,867,899 enabled the Council to start improving the supply of English teachers and teaching material for overseas and other work in accordance with Government decisions contained in the White Paper on Overseas Information Services. Further activities will be possible in 1958–59 with the increase of nearly £650,000 on the original estimates for 1957–58. For this year the Council is recruiting, or helping to recruit, on improved terms, for about seventy overseas teaching posts in English in schools, training colleges and universities, chiefly in Asian countries. It is also co-operating closely with a unit established by the Ministry of Education to assist in placing satisfactorily the returning teacher. Much is being done abroad to help overseas teachers of English, and the Council has also been closely associated with the new School of Applied Linguistics in the University of Edinburgh, to which one of its most experienced English-teaching specialists is being seconded. The Council is contributing £5,000 towards the establishment of an Overseas Visual Aids Centre to further increased and more efficient use of visual and audio-visual aids in formal and informal education overseas.

The specialist tours arranged by the Council include an advisory unit at the request of the Burmese Government of Prof. H. F. Humphreys and Mr. W. J. Deacon to examine and report on the state of education in Burma, a visit to Turkey of thirteen British surgeons, headed by Sir Clement Price Thomas, and tours of Prof. C. Wells to Pakistan, Burma, Thailand, the Philippines, Australia and Canada, to advise on surgical techniques and radiological services, and of Sir Alister Hardy to Pakistan, Thailand, Hong Kong and Japan to inspect oceanographic institutions. More than 1,800 visits of scientific specialists to and from Britain were assisted by the Council in one way or another in 1957–58, representing 35 per cent of the total for all subjects and professions. In numbers this represents 42·6 per cent out of 4,902 visitors to the United Kingdom under the auspices of the Council, compared with 18·5 per cent in social studies, 14·8 per cent in education and 10·1 per cent in medicine; for 1951, the corresponding figures were 23·5, 15, 14·5 and 10 per cent, respectively. There has been a striking growth in recent years of the Council's responsibilities as agents for the United Nations Specialized Agencies, the Colombo Plan, the Baghdad Pact and other international agencies offering training in the United Kingdom, and in 1957–58 1,012 such visitors were cared for in the United Kingdom by the Council, compared with 191 in 1950–51. About £380,000 a year is administered by the Council for international and overseas organizations.

The fifteen short specialist courses arranged annually included one on the economic problems of developing countries, for senior officials and administrators, and in 1957 study tours were arranged for 67 groups, many from British Colonial territories, while in the autumn of 1957, 300 Soviet students and young people were invited to visit the United Kingdom for periods of three weeks. This programme has made considerable progress on an exchange basis with the co-operation of leading student and youth organizations in the United Kingdom, while the Council has also placed a number of postgraduate Soviet scholars in British universities and promoted exchange visits of teachers of English and Russian to summer schools in the United Kingdom and the U.S.S.R.

The number of overseas students in the United Kingdom rose in 1957 to 35,000 and is now about 38,000, less than a third of whom are at universities. In 1957, 7,782 students were met on arrival, 4,644 were assisted to find permanent accommodation, 386 becoming permanent residents in the Council's own residences, which also provided transit accommodation for 1,692 students. New premises were acquired during 1957–58 in Hull, Leeds, Liverpool and Nottingham. Some 13,259 overseas students attended British Council vacation and week-end courses and study visits, and private hospitality was arranged for 5,481 students. Travel grants to university teachers on study leave and to postgraduate workers totalled thirty-six (twelve from Australia) for visits to the United Kingdom and four for visits from the United Kingdom, and under the younger research workers interchange scheme twelve visited the United Kingdom and twenty-five from the United Kingdom visited six European countries.

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* British Council. Annual Report 1957–1958. Pp. vi+111+8 plates. (London: British Council, 1958.)

COSMOGENIC NOBLE GASES IN THE WASHINGTON COUNTY METEORITE

By OLIVER A. SCHAEFFER and DAVID E. FISHER
Brookhaven National Laboratory, Upton, Long Island, New York

AN iron meteorite, designated the Washington County or Arickaree meteorite, was discovered in a Colorado wheat field in 1927. Eugene King, the finder, seemed to observe evidence of heat in the soil in which it was embedded, and as in addition almost no evidence of rusting is observed, it would appear that the meteorite fell recently. A proposed date of fall is 1916[1]. It contains 9·3 per cent nickel[1] and does not show a Widmanstätten pattern; it is thus classified as a nickel-rich ataxite. In this experiment, pieces of the meteorite, supplied to us by the Harvard Museum through the courtesy of Dr. E. L. Fireman, of the Smithsonian Astrophysical Laboratory of the Harvard Observatory, were examined by mass spectroscopy to determine if noble gases, originating from spallation effects induced by cosmic rays, were present.

There has been discussion as to whether the Washington County meteorite is indeed a meteorite, or whether it might be an example of terrestrial iron. The overall appearance of the slab as found was similar to what might be expected of machined iron, as if it might have been discarded from a cast. In addition, voids were observed distributed throughout the mass, in contrast to other known meteorites. The presence of helium-3 was discovered in the present experiment, thus establishing definitely that the metal was exposed to extra-terrestrial cosmic radiation, and is, in fact, a meteorite.

Samples weighing 0·1–0·2 gm. were melted in a graphite crucible at a temperature of approximately 2,000° C. by means of an induction heater. The entire gas line leading from the sample to the mass spectrometer, including the samples of standard gas, were maintained in vacuum at pressures not above 10^{-6} mm. of mercury. The line was constructed of 'Pyrex' glass, formula 1720, which effectively inhibits the diffusion of helium through the walls.

After melting, the escaped gases were purified by passing them over copper oxide and calcium heated to 600° C. They were then introduced into the mass spectrometer and the helium-3, helium-4, argon-36 and argon-38 were quantitatively determined. The argon was then adsorbed on charcoal at liquid-nitrogen temperatures, and the neon isotopes 20, 21 and 22 were measured. Standard amounts of the above gases were added to the sample in the mass spectrometer and the equipment was thus calibrated. Blank determinations were run at the specified crucible temperature before each sample. A blank was run after each sample at a crucible temperature approximately 50° higher. This blank was found to contain approximately 3–5 per cent of the noble gases, indicating that each sample was well outgassed. This amount was then added to the results originally obtained.

It is expected that the results obtained for all isotopes except neon-20 are good to within 10 per cent. The value for neon-20 could not be determined so accurately because of background due to doubly charged argon-40, and it is felt that the true value may vary from that given by up to a factor of 2. No number is reported for the abundance of argon-40 in the meteorite because of this large background of atmospheric argon. The correction that was applied to the argon-36, however, was only 10–20 per cent of the peak value, and that applied to argon-38 was less than 5 per cent. The accuracy of the mass spectrometer was tested by bombarding a gold target with α-particles in the Brookhaven cyclotron, the incident intensity being measured with a Faraday cup[2]. The target was melted in the mass spectrometer and the helium-4 was measured. The results agreed with those measured by the Faraday cup to within 5 per cent. The measured results are shown in Table 1.

Table 1

	Abundance in units of 10^{-8} c.c./gm.						
Sample No.	He-3	He-4	Ne-20	Ne-21	Ne-22	Ar-36	Ar-38
	193	2,700	8	2·14	2·6	5·6	7·8
II	193	3,100	5	1·98	2·2	5·1	7·2
Average	193	2,900	7	2·06	2·4	5·4	7·5

A comparison with other meteorite data can most profitably be made on the basis of rare-gas ratios reported for iron meteorites with high (of the order of 10^{-6} c.c./gm.) helium-3 contents. For example, for the ratio helium-3/neon-21, values are reported ranging from 72 to 130. Our value is 94, in the range of these previous numbers. For the ratio helium-3/argon-38, values are reported[3,4] in the interval 15–40. Our value is 26.

The ratio helium-4/helium-3, however, is approximately five times that previously found for comparable meteorites.

The early experimenters on noble gases in meteorites attributed the helium-4 content to uranium and thorium disintegrations[5], and, on the basis of measured helium-4 and uranium–thorium contents, they determined ages for the meteorites. No general consistency was found in the ages determined for various meteorites by this method. Since these early experiments, two objections to the technique have been raised. From measured amounts of other noble gases in meteorites[6], it is now thought that practically all the helium-4 is, in fact, due to spallation effects from nuclear reactions induced in the meteorite by high-energy cosmic rays[7]. The other objection, raised by Urey[8], is that the dates may be in error due to the diffusion of radiogenic helium along crystal structure boundaries, an argument being advanced that the majority of the uranium will segregate itself along these boundaries. Reed and Turkevich[9] have measured the uranium content of two iron meteorites by neutron activation and have set an upper limit of 10^{-10} gm./gm.—an amount insufficient to account for the helium-4 actually found in meteorites.

In the present experiment the high value for the ratio helium-4/helium-3 may indicate that a considerable portion of the helium-4 is in this case radiogenic. It would thus be possible to estimate the cosmogenic helium-4 content by the measured helium-3 content and the known value of this ratio in other iron meteorites. We have assumed a helium-3/helium-4 ratio of 0·25, natural abundance of uranium-235 and uranium-238 in the meteorite, a thorium-232/uranium-238 ratio of 4, and an age of 10 × 10^9 years[10], and have thus estimated the uranium-238 content of this meteorite to be 3 × 10^{-10} gm./gm. An age of 5 × 10^9 years changes this estimate to 1 × 10^{-8} gm./gm. These values are well within the sensitivity of the neutron activation method of analysis[11] and show a significant variation at the two estimated ages. Accordingly, an attempt will be made in this laboratory to measure the uranium content by this method and possibly obtain a helium–uranium date for the meteorite. The grain boundaries along which the helium might leak out are absent to a large extent in the ataxite structure, and this objection should be greatly reduced.

The argon-36/argon-38 ratio has been measured in other iron meteorites[3,4] and usually found to be 1·6. The value found here for the Washington County meteorite is 1·4. This may be due to the high nickel content, spallation reactions from the predominant nickel-58 isotope perhaps favouring the formation of argon-36; on the other hand, the difference between these values may not be significant.

We wish to express our appreciation for the technical assistance of Mr. J. Densieki and for several valuable discussions with Dr. E. L. Fireman.

This research was carried out under the auspices of the U.S. Atomic Energy Commission.

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ABSORPTION SPECTRUM AND DECAY KINETICS OF THE METASTABLE STATE OF CHLOROPHYLL *b*

By PROF. STIG CLAESSON, LARS LINDQVIST and BERTIL HOLMSTRÖM
Institute of Physical Chemistry, University of Uppsala

As part of an extensive investigation of the photochemistry of chlorophyll we have studied the absorption spectrum and decay scheme of the metastable state of chlorophyll *b* in benzene solutions free from oxygen. As some related work in this field has recently been reported[1,2], a short presentation of some of our results may be of interest.

Using the flash photolysis and flash spectroscopy technique[3], the absorption spectrum of the metastable state was determined from 290 up to 840 mμ from measurements during the exciting flash. The red or blue part of the emission spectrum from the flash lamp was isolated for excitation. With the high-energy flash (that is, 400 μF. at 5 kV., and a 60 μsec. duration) at our disposal[4], it was possible to achieve complete conversion to the metastable state. The total absence of chlorophyll *b* in the ground-state increased the accuracy of the absorption spectrum measurements, especially in the region of the absorption peaks of the ground-state.

The optical arrangement was such that no detectable stray light from the exciting flash entered the recording system. Each photographic plate was individually calibrated by a set of seven grey filters.

The concentration of chlorophyll *b* in the benzene solutions was 0·35 × 10^{-6} *M*, and the length of the optical path was 60 cm. At such a length the absorption of oxygen-containing benzene is appreciable up to 350 mμ, therefore the solvent for the blank spectra had to be carefully degassed.

Fig. 1 indicates the absorption spectrum of the metastable state, as obtained from three independent sets of experiments. The ultra-violet region was obtained from a series of 3 plates, 7 spectra; the visible region from 8 plates, 14 spectra; and the infra-red region from 5 plates, 7 spectra. As is seen, the absorption curves from these three wave-length regions tie together in a very satisfactory manner without any corrections. The points obtained from the flash experiments, corresponding to the ground-state of

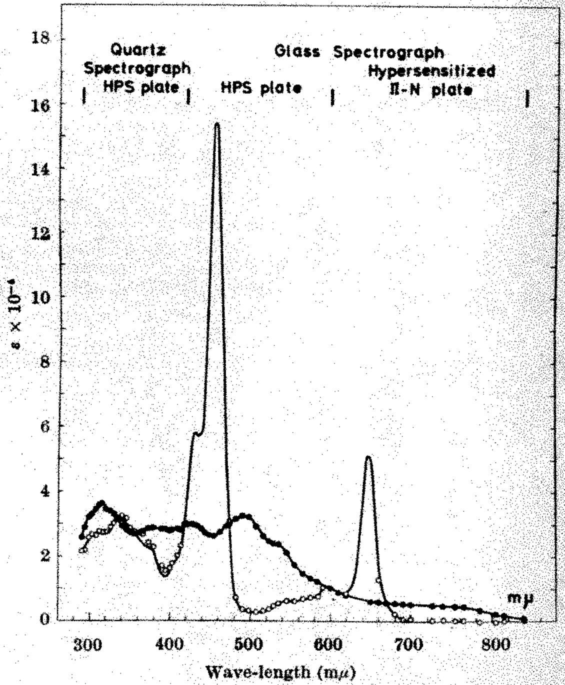

Fig. 1. The absorption spectra of chlorophyll *b* in benzene in its ground-state (○) and in its metastable state (●). The points were obtained photographically from flash experiments, while the solid curve for the ground-state was determined spectrophotometrically. The types of plates used for the different wave-length regions are indicated

chlorophyll *b*, fit very closely to the absorption curve as determined by standard spectrophotometry. These points were corrected for an excitation of 5 per cent caused by the spectrograph flash lamp, this having been established in separate experiments.

The spectrum in Fig. 1 was obtained using only red light for the excitation of the chlorophyll *b*, yet some spectra were also recorded using blue light. The absorption spectra obtained in each case were identical.

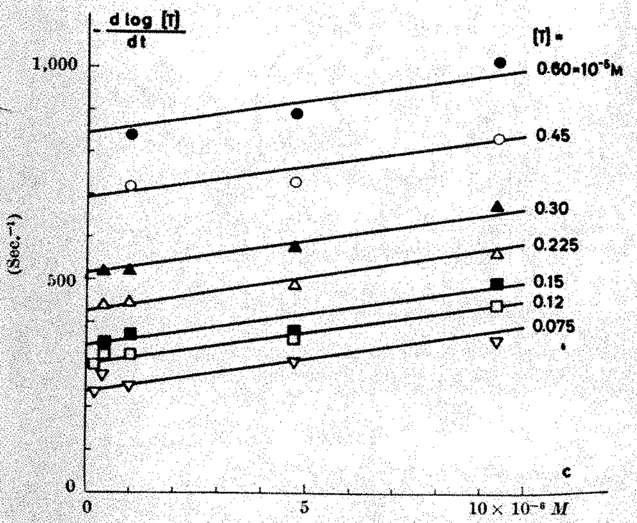

Fig. 2. The extrapolation of $-d\log(T)/dt$ to $c = 0$. The slope gives the value of k_2

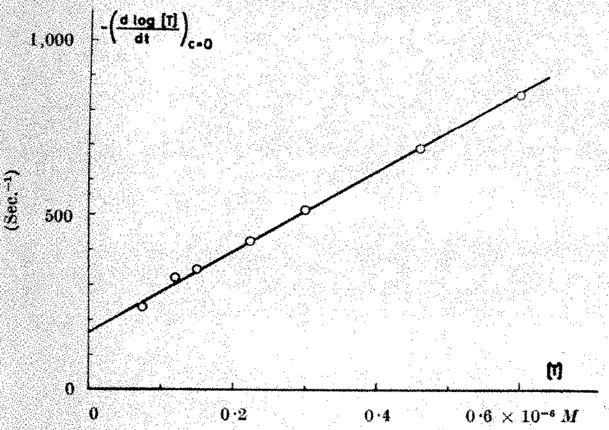

Fig. 3. The value of $-d\log(T)/dt$ at $c = 0$ from Fig. 2 plotted against (T). The slope of the line gives $k_3 - k_2$, and the intercept gives k_1

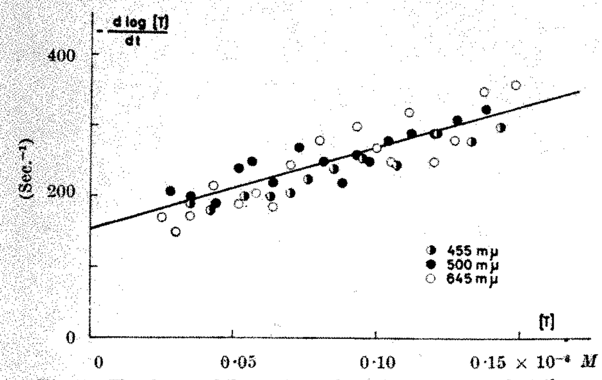

Fig. 4. The decay of the metastable state, as measured at three different wave-lengths, where the total concentration of chlorophyll *b* was 0·2 × 10⁻⁶ *M*

The kinetic measurements were carried out over the concentration range of 10^{-7} to 10^{-5} *M*, with optical path-lengths of 60 and 20 cm. The transient decay was studied both photographically and photoelectrically, principally the latter.

For all wave-lengths studied (that is, 410–645 mμ) the decay was in agreement with a scheme proposed by Livingston[5]. It may be represented as follows, where *T* indicates the metastable state and *S* the ground-state of chlorophyll *b* :

$$T \rightarrow S \tag{1}$$

$$T + S \rightarrow S + S \tag{2}$$

$$T + T \rightarrow S + S \tag{3}$$

Then, if the total concentration of chlorophyll *b*, $(T) + (S)$, is denoted by *c*,

$$-\frac{d(T)}{dt} = k_1(T) + k_2(T)(S) + k_3(T)^2 \tag{4}$$

$$-\frac{d\ln(T)}{dt} = k_1 + k_2 c + (k_3 - k_2)(T) \tag{5}$$

For the determination of the three constants in equation (5), we have relied chiefly on values obtained at 500 mμ. Extrapolations to $(T) = 0$ and $c = 0$ are needed, these being carried out in either order. Figs. 2 and 3 illustrate one of these possibilities. For each total concentration the decay-rate is determined at some selected values of the concentration (T) of the metastable state. For each (T), an extrapolation to $c = 0$ is performed (Fig. 2) to give $(d\log(T)/dt)_{c=0}$, the slope defining the constant k_2. The ordinates for $c = 0$ are plotted in Fig. 3 against (T), the intercept giving k_1 and the slope giving $k_3 - k_2$. Each point in Fig. 2 is based on two or three different experiments consisting of 10–30 oscillograms. The results for the three constants are :

$$k_1 = 0{\cdot}4_0 \times 10^3 \text{ sec.}^{-1}$$
$$k_2 = 0{\cdot}03_5 \times 10^9 \text{ sec.}^{-1}\, M^{-1}$$
$$k_3 = 2{\cdot}3_5 \times 10^9 \text{ sec.}^{-1}\, M^{-1}$$

In connexion with the determination of the absorption spectrum of the metastable state shown in Fig. 1, kinetic experiments were also performed photographically, these revealing four isosbestic wave-lengths. During the photoelectrical measurements of the kinetics, two of these wave-lengths, 418 and 474 mμ, were further confirmed. No change in extinction at these two wave-lengths was observed. From this it is concluded that only one metastable state is present under these experimental conditions. A further proof is the good agreement among the decay rates for different wave-lengths. This is illustrated in Fig. 4, where the same kinetics is obtained at the three wave-lengths shown.

The chlorophyll *b* was prepared by Zscheile and Comar's method[6]. A small amount of water was purposely left in the stock solution, thus avoiding difficulties in interpretation due to superdryness of the final solutions. The solutions were degassed by five cycles of freezing, evacuating and melting.

A detailed account of this work will appear in the near future.

The investigation was supported by a grant from the Rockefeller Foundation.

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IN VITRO ANALYSIS OF A MAMMALIAN TUMOUR VIRUS

By Dr. LEO SACHS, Dr. MARIAN FOGEL and ERNEST WINOCOUR

Department of Experimental Biology, Weizmann Institute of Science,
Rehovoth, Israel

THE classical studies of Ellerman and Bang[1] and Rous[2] first demonstrated that viruses could be involved in the origin of neoplastic growth. Several tumour viruses have now been isolated from birds and frogs, and in mammals viruses are known to be associated with papilloma in rabbits and some other species, fibroma in rabbits, and mammary tumours in mice[3]. In 1951, Gross[4] reported his original observations on the viral origin of a spontaneous lymphatic leukæmia in mice. This observation has been fully confirmed[5], and since then viruses have been found to be associated with some other types of leukæmia[6], parotid tumours and sarcomas[7] and various other neoplasms in mice and hamsters[8]. All these observations in mammals, with the exception of those of Stewart *et al.*[8], have been made after inoculation of filtrates from a tumour directly into a susceptible host. It seems clear that even for the actual isolation of viruses such a procedure has limitations; and such studies, by themselves, can, of course, give little direct information on cell virus relationships. It would appear that an answer to the basic questions relating to tumour viruses in mammals can only be given by combining an *in vivo* with an *in vitro* analysis.

It has been shown by Stewart *et al.*[8] that a virus originating from a spontaneous lymphatic mouse leukæmia can be maintained in tissue culture, and that when harvested from such cultures it can produce a variety of tumours. We are indebted to Drs. Stewart and Eddy for sending us some of their line 3919 of this virus, which they have termed polyoma virus, and the present report deals with some *in vitro* studies with this material.

The polyoma virus was routinely grown in Petri dishes on monolayers of Swiss mouse embryos, incubated in a humidified atmosphere containing 10 per cent carbon dioxide[9], using a medium of 0·5 per cent lactalbumin hydrolysate in Earle's saline and 20 per cent horse serum. Our first passage in culture of the material received from Stewart and Eddy gave a clear cytopathogenic effect, as a result of which cells become detached from the glass, often in grape-like clusters, and degenerate; and a cytopathogenic effect with this virus has also recently been reported by these authors[10]. In addition to embryo, cells of adult mouse kidney and bone marrow were tested and a cytopathogenic effect was produced in both these tissues. The demonstration of an observable effect on cells in culture has made it possible to develop a plaque assay for this virus similar to that originally developed for viruses such as poliomyelitis[9]. The cytopathogenic effect could be localized into foci under agar; the technique will be described in detail elsewhere. Plaques appeared as small discrete foci of degenerate cells. Isolations from plaques should give pure lines of virus and these are being tested for the type of tumours that they produce.

Table 1. SPECTRUM OF RED BLOOD CELLS AGGLUTINATED BY POLYOMA VIRUS

Red blood cells	Hæmagglutination titre 1: Virus-infected t.c. fluid	Hæmagglutination titre 1: Normal t.c. fluid	Red blood cells	Hæmagglutination titre 1: Virus-infected t.c. fluid	Hæmagglutination titre 1: Normal t.c. fluid
Guinea pig	2,048	8	Sheep	512	—
Rat	256	128	Goat	—	—
Mouse (Swiss)	1,024.	64	Dog	1,024	4
Hamster	8	8	Cat	16	16
Frog (*Hyla arborea*)	4,096	16	Chick (1 day old)	1,024	8
Human (O)	128	8	Hen (adult)	2,048	—
Monkey			Turkey	2,048	8
(rhesus)	512	4	Pigeon	32	32
(patas)	16	8	Goose	16	16
(baboon)	32	4	Duck (*Anas coxhas*)	16	16
Horse	—	—	(*Anas moscant*)	512	16
Cow	—	—			

We have also found, as recently reported by Eddy *et al.*[10], that the polyoma virus can hæmagglutinate at refrigerator, but not at higher, temperatures. The spectrum of its agglutinability for red blood cells from different species is shown in Table 1. Guinea pig cells have been routinely used with titres up to 1 : 4,096. 0·15 c.c. of a 1 per cent suspension of red blood cells in saline was added to 0·5 c.c. of each dilution of virus, and the tests read after 3 hr. or overnight. The end-point used was that of a full agglutination of the red blood cells. The hæmagglutinating particles are stable after heating at 56° C. for 30 min., but destroyed after 30 min. at 66° C. When taken from the refrigerator and placed at room temperature, the agglutination is destroyed and the red blood cells settle normally. The virus is eluted readily at 37° C., and the cells after elution can again adsorb virus. Hæmagglutination inhibition was produced by antibodies against the virus, and titres up to 1 : 81,920 have been obtained.

With the establishment of the plaque and hæmagglutination assays, it became possible to make quantitative *in vitro* determinations on the growth of the virus in tissue culture.

Two separate experiments, using two different inocula, were carried out on the growth of the polyoma virus on mouse embryo monolayers (Table 2). In Exp. 1 there was no change of medium throughout the experiment so that the cumulative amount of virus could be determined. A series of monolayers were inoculated with virus (3 hr. absorption followed by washing), and at the time intervals shown in Table 2 the amount of virus in the medium (free virus) and in the medium plus cells (total virus) was determined by hæmagglutination. Total virus was determined after subjecting the entire cultures (medium plus cells) to five cycles of freeze thawing at − 20° C. In Exp. 2 a series of monolayers were inoculated as previously and the amount of virus released into the medium was determined during the first 24-hr. and two subsequent 48-hr. periods. After

Table 2. GROWTH OF POLYOMA VIRUS ON MOUSE EMBRYO MONOLAYERS

			Days post-inoculation			
			1	3	5	7
Exp. 1 (cumulative)	'Total virus' by hæmagglutination assay*		8	256	256	256
	'Free virus' by hæmagglutination assay		8	32	32	64
Exp. 2 (virus after a 24-hr. and two 48-hr. periods)	'Free virus' (Series 1) by hæmagglutination assay	*A*	16	512	128	—
		B	16	512	128	—
		C	16	512	128	—
		D	16	1,024	128	—
	'Free virus' (Series 2) by hæmagglutination assay	*A*	8	512	128	—
		B	8	256	128	—
	'Free virus' (Series 2) by plaque assay†	*A*	11	234	114	—

* Hæmagglutination titres expressed as reciprocal of complete hæmagglutination end-point per 0·5 ml. Hæmagglutination titre of control plates was 8.

† Plaque assay expressed as mean number of plaques (4 plates) per 0·2 ml. at 1 : 10 dilution.

Exp. 1, strong cytopathogenic effect after 7 days. Exp. 2, strong cytopathogenic effect and complete destruction of monolayer after 5 days.

each collection date all the cultures were washed and fresh medium added. This experiment was carried out in two series. In series 1 the samples tested at day 1, 3 and 5 were taken from the same plate in each of the four replicates (*A–D*). In series 2, the samples tested at day 1, 3 and 5 in the two replicates (*A* and *B*) were taken from different plates. The virus in series 1 was assayed by hæmagglutination and in series 2 by hæmagglutination and plaques. In all experiments the virus assayed by hæmagglutination was from supernatants after centrifugation at 3,000 r.p.m. in a clinical centrifuge for 10 min.

The results of both experiments clearly show that there has been multiplication of the virus on mouse embryo cultures, and that virus is released over a long period of time. Little or no virus could be detected during the first 24 hr., and the highest level of virus production and release in Exp. 2 was during the period between the first and third day. The drop in virus during the next 48-hr. period in this experiment may have been due to the early appearance of a strong cytopathogenic effect. It can also be seen from Exp. 2 that the results obtained from plaques follow that obtained by hæmagglutination. The results of Exp. 1 show that the free virus was less than the total virus throughout the experiment, indicating that a significant amount of virus produced remains associated with cells and is not released immediately into the medium. A similar situation has been noted in viruses such as vaccinia and sheep pox[11]. The behaviour of the polyoma seems to differ in some respects from that reported for the Rous chicken virus[12].

These results with the polyoma demonstrate that with the use of the plaque assay developed it is now possible to produce pure lines of mammalian tumour virus, and that furthermore it is now possible to use *in vitro* techniques both for the characterization of mammalian tumour viruses and for the analysis of cell virus relationships.

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AGGREGATION OF COD MYOSIN DURING FROZEN STORAGE

By J. J. CONNELL

Food Investigation Organization, Department of Scientific and Industrial Research,
Torry Research Station, Aberdeen

MONODISPERSE cod myosin has a pronounced tendency to aggregate when neutral solutions of it are left undisturbed at 0° C.[1,2]. The aggregation is characterized by the appearance in the ultracentrifuge picture of the solution of at least one, and sometimes two, discrete components which sediment faster than myosin and which, on the basis of their sedimentation coefficients, can be identified as a side-to-side dimer and trimer, respectively. It has now been found that this aggregation proceeds in the frozen state.

Solutions of monodisperse cod myosin (0·4–0·6 per cent) in 0·45μ potassium chloride with 0·05μ phosphate buffer, *p*H 7·5, contained in $\frac{5}{8}$ in. × 2 in. thin-walled plastic tubes, were frozen by immersion in a bath of chloroform-solid carbon dioxide at about −78° and then stored for 3 or 4 days at −7, −14, −22, −29 and −78°. They were then thawed by placing the tubes in ice water so that the final temperatures never rose above 0°. Figs. 1 (*d–h*) show the ultracentrifuge pictures obtained immediately after the solutions were thawed. Fig. 1 also shows pictures of the original solution and the original solution after standing 3 days unfrozen at 0°. It is evident that (omitting Fig. 1*b*) least aggregation has occurred in the unfrozen solution kept at 0° and in the solution kept at −29° for 4 days, the amount of monomeric myosin in these solutions being still so great that the top of the schlieren peak is not registered and the typical bar effect parallel to the meniscus is produced. Most aggregation has occurred in the solution kept at −14° and −22°, most of the myosin having formed heavy polydisperse material which has sedimented to the bottom of the cell before the photographs were taken, leaving small residual amounts of monomeric and oligomeric myosin in the supernatant solution.

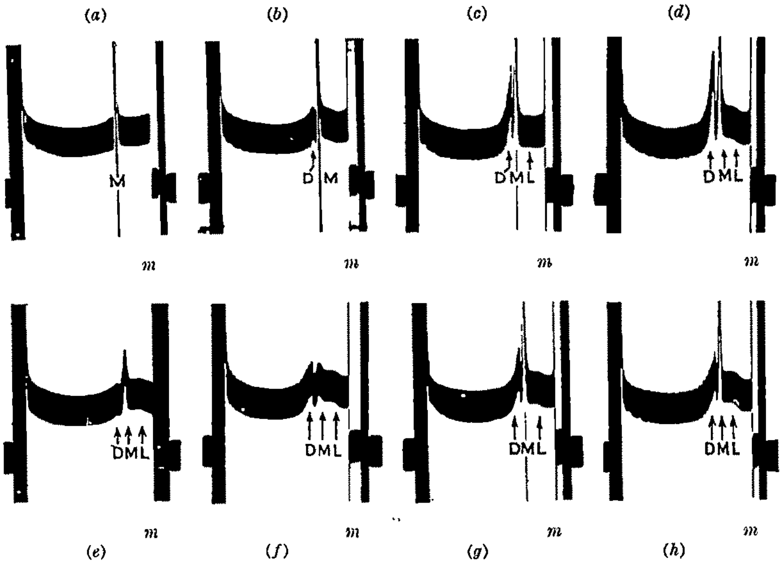

Fig. 1. Sedimentation pictures of cod myosin solutions. *a*, original solution; *b*, *a* frozen to − 78° and thawed at 0° five times in succession; *c*, *a* left unfrozen at 0° for 3 days; *d*, *e* and *f*, *a* frozen to − 78°, stored for 3 days at − 7, − 14 and − 20°, respectively, then thawed at 0°; *g* and *h*, *a* frozen to − 78°, stored for 4 days at −29 and −78°, then thawed at 0°. Sedimentation at 59,780 r.p.m. occurs from right to left. *m* is the meniscus; *D*, *M* and *L* denote, respectively, dimeric and monomeric myosin and a light component. Exposures taken: *a*, 96; *b*, 75; *c*, *d*, *e*, *g* and *h*, 69; and *f*, 53 min. after reaching full speed. Temperature of rotor: *a*, 2·20; *b*, 4·70; *c*, 1·95; *d*, 4·40; *e*, 5·30; *f*, 7·15; *g*, 2·25; and *h*, 3·65° C.

At −7° and −78° aggregation has proceeded to some intermediate stage.

This result has been confirmed with two other different preparations of cod myosin. Solutions kept frozen for about 7 days and then thawed, particularly those at −14° and −22°, often contain blobs of weak transparent gel and fine precipitates. The operation of freezing and thawing even when carried out five times in succession on the same solution produces only traces of material which sediments faster than myosin (Fig. 1*b*).

Two experiments with myosin frozen in solutions containing 0·45μ sodium chloride and 0·45μ potassium sulphate (both with 0·05μ phosphate buffer, *p*H 7·5) showed that the pattern of aggregation is different from that in solutions containing potassium chloride. In solutions containing 0·45μ sodium chloride aggregation is much the same at −7, −14 and −22° but less at −29 and −78° than at the higher temperatures; in solutions containing 0·45μ potassium sulphate aggregation is pronounced at −7° and becomes progressively less at the lower temperatures. These observations suggest that both the eutectic temperature of the solution (about −1·5, −11 and −21° for potassium sulphate, potassium chloride and sodium chloride, respectively) and the temperature of storage are important factors in determining the rate of aggregation. Snow[3] has suggested that the rate of insolubilization of haddock actomyosin during frozen storage of its solutions is greatest at temperatures below the eutectic point.

Fig. 1 also shows that a component (*L*), which sediments more slowly than myosin, is formed during frozen storage and possibly also during equivalent periods of storage in the unfrozen state at 0°. The largest amount of this presumed dissociation sub-unit of myosin appears to be produced at −78°.

The mechanism of these complex changes is unknown; but they occur without any appreciable intramolecular change because the specific rotation and numbers of sulphydryl groups titratable with N-ethylmaleimide do not change during the first 7 days storage at −7°, for example. It has been noted also that the aggregation of cod myosin in the unfrozen state at 0° apparently does not proceed by a conversion of sulphydryl groups into disulphide bridges because (1) the aggregation is not inhibited by the addition of 0·01 *M* monothiglycol, and (2) myosin the reactive sulphydryl groups of which have been blocked by N-ethylmaleimide aggregates just as rapidly as untreated myosin.

Further aspects of these changes are being investigated, particularly in relation to the toughness and loss of water-holding capacity which develop during the frozen storage of fish muscle. The development of toughness in stored fish must ultimately involve some sort of intermolecular cross-linking or aggregation reaction of the proteins. The changes occurring during the frozen storage of whole muscle have been often ascribed to protein 'denaturation'[4-9], the implication being that some form of unfolding or configurational alteration of the molecules occurs. However, the experiments described here suggest that some part, or the whole, of these changes may involve aggregation of native configurationally unchanged molecules. This notion is supported by a number of scattered observations. Thus, no change in the numbers of sulphydryl groups of that part of the fish actomyosin complex which remains soluble after frozen storage could be found[7,10]. (In one investigation[6], apparently random variations in the 'masked' sulphydryl groups of whole fish muscle during frozen storage did occur in some circumstances.) In addition, the apyrase activity of whole fish muscle does not decline during conditions of frozen storage which undoubtedly lead to the development of toughness of the tissue and insolubility of the myofibrillar proteins[11]. Partmann's suggestion[11] that the explanation for this phenomena lies in the fact that the *H*-meromyosin sub-unit, which possesses all the adenosine triphosphase activity of the myosin, is reported[12] to be unaffected by freezing while *L*-meromyosin is rendered insoluble, remains to be investigated.

This work was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Verification of General Relativity by means of Artificial Planets

THE evidence from observation[1] for the relativity advance of the perihelia of planetary orbits depends primarily on the rate of advance of the perihelion of Mercury. I have discussed[2] the possibility of basing a verification of this result of general relativity on the motion of minor planets of high eccentricity, in particular on the motion of (1566) Icarus. La Paz[3] has pointed out the further possibility of a check based on observation of an artificial satellite of the Earth. The recent Russian success in creating an artificial planet of the Sun has removed from the realm of speculation the use of such a body in verifying the predictions of general relativity. The purpose of this communication is to show that the controllable orbit of an artificial planet can be selected to yield a very large relativity advance of perihelion under certain conditions.

The expression of general relativity for the angular advance ε (in radians) of a planetary perihelion per revolution is:

$$\varepsilon = 6\pi GM\,[c^2 a\,(1 - e^2)\,]^{-1} \qquad (1)$$

where a is the semi-major axis and e the eccentricity of the orbit, M is the mass of the Sun, G is the gravitational constant, and c is the speed of light. It will be assumed that propulsion of the artificial planet terminated in the immediate neighbourhood of the Earth. Hence, the minimum possible value of a is approximately $\frac{1}{2}$ A.U. (corresponding to $e \sim 1$), fixed by the fact that the aphelion point cannot lie inside the Earth's orbit. As in the corresponding case for a minor planet[2], it follows that a significantly large relativity advance for an artificial planet is possible only for large eccentricity.

When the approximation $e \sim 1$ is made, equation 1 can be written in the form:

$$\varepsilon = (3\pi GM/c^2)q^{-1} \qquad (2)$$

where $q = a\,(1 - e)$ is the perihelion distance of the planet's orbit from the Sun's centre. For the case in question, equation 2 states that the relativity advance per revolution depends only on the reciprocal of the perihelion distance. If the semi-major axis a is measured in astronomical units, the annual advance v (in radians) of the perihelion is:

$$v = \varepsilon/a^{3/2} \qquad (3)$$

since in this case the period P in years is given by $P = a^{3/2}$. In the same units, one must have:

$$2a - q \geqslant 1 \qquad (4)$$

if the aphelion point is not within the Earth's orbit. The minimum possible value of q in equation 2 clearly is fixed by $q = R_\odot$, where $R_\odot$ is the solar radius. The corresponding point of tangency of the orbit with the Sun's surface at perihelion is the only point of contact, since the semi-parameter (half the latus rectum) given by $p = a\,(1 - e^2)$ always exceeds the perihelion distance q for an elliptical orbit. The value $v_{\text{max.}}$ of the maximum possible perihelion advance v corresponding to the minima $q = R_\odot$ and $a = (1 + R_\odot)/2$ from (4) is:

$$v_{\text{max.}} = 11{\cdot}6'' \qquad (5)$$

annually. This figure can be compared with centennial advances of 43″ and 10″ for Mercury[1] and Icarus[2] respectively, which are less by orders of magnitude.

In practice, the grazing contact with the Sun to which equation 5 corresponds is undesirable, since the perihelion point must be selected so that loss of mass of the artificial planet in its passage through the extended atmosphere of the Sun is negligible. The effect on v of varying q (in terms of the solar radius as unit) is shown in Fig. 1, with the semi-major axis a (in A.U.) as parameter, over limits set by inequality 4. One sees that a reasonable range of q and a exists over which the perihelion advance v of the artificial planet exceeds that of Mercury. In the latter case, the value of v is shown in Fig. 1 as a function of q, although the approximation $e \sim 1$ is inapplicable (v is large because a is small). In common with the principal planets of mean distance greater than that of Mercury, the Russian artificial planet does not meet the condition of high eccentricity for a significant relativity advance. The pertinent elements of its orbit are $e = 0{\cdot}148$ and $a = 1{\cdot}16$ A.U., as reported in the current Press[4]. From equation 1, the corresponding relativity advance of perihelion is $v = 2{\cdot}7''$ per century, which is less than the figure (3·8″) for the Earth.

As is true also for the natural planets, the possibility of basing an observational test of the relativity formula 1 on the motion of an artificial planet depends on the possible precision in the measurement of the perihelion motion, as well as on the magnitude of the relativity advance. This precision can be

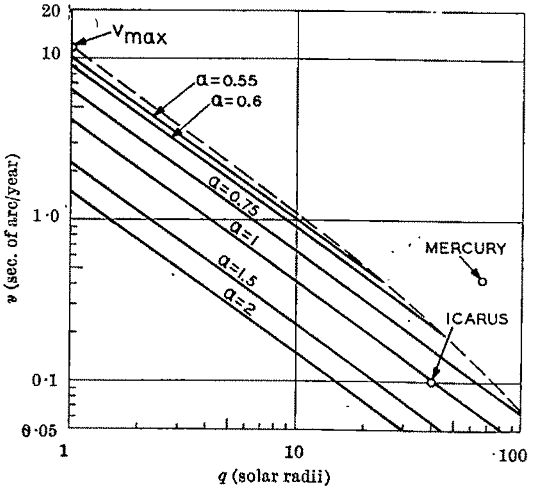

Fig. 1. The relativity advance v of the perihelion of an artificial planet of high eccentricity, as a function of its perihelion distance q (in units of the solar radius) from the Sun's centre, with the semi-major axis a (in astronomical units) as parameter. The dashed line corresponds to inequality (4). Values for Mercury and Icarus are shown for comparison. Scales are logarithmic

measured in the case of the principal planets by a figure of merit α defined by Clemence[1], and for the minor planets by a generalization of this parameter given by me[2]. It seems premature at this time to attempt evaluation of a corresponding figure of merit for an artificial planet. However, one important consideration associated with the factor l (the fraction of the period over which observations can be made) entering the figure of merit α can be noted. Because of the small size of an artificial planet relative to those of the observable minor planets, optical or radar observation is possible only when the object is in the immediate vicinity of the Earth. To optimize the number of passages in which observation is possible, it is accordingly necessary that the ratio of the planet's period to that of the Earth equal closely a ratio of small integers n and m. This condition requires that:

$$a \sim (n/m)^{2/3} \qquad (6)$$

for a in A.U. In time, of course, the effect of perturbations will tend to destroy the relationship 6, and this circumstance may ultimately limit the amount of data obtainable from an artificial planet, and the corresponding precision in fixing the relativity advance.

JOHN J. GILVARRY

Research Laboratories,
Allis-Chalmers Manufacturing Co.,
Milwaukee, Wisconsin.
Jan. 14.

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Effect of Magnetic Activity on Drifts of the *F*2 Region

OBSERVATIONS of ionospheric drift made at high-latitude stations by different methods has been examined by several investigators with the view of studying the dependence of speed and direction of drift on magnetic activity. From such studies, it has generally been concluded that speeds of drift of the $F2$ region increase with increase of magnetic activity. As it was found[1] that drifts of the $F2$ region at Waltair show a significantly different behaviour from those at high latitudes, we have examined the results of the $F2$ drifts at Waltair with the view of ascertaining the nature and the extent of this dependence on magnetic activity.

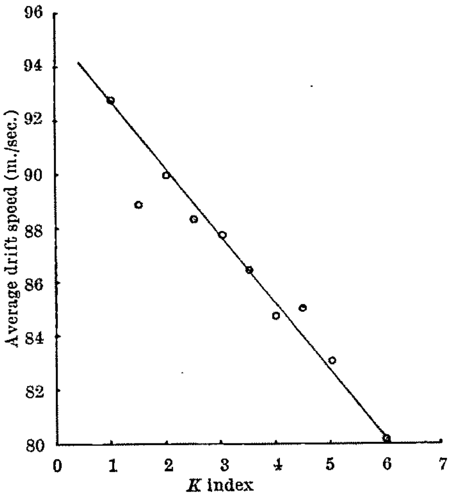

Fig. 1. Variation of speed of drift of the $F2$ region with geomagnetic K index

For the purpose of the present analysis, observations made at Waltair (mag. lat. 9° 30′ N.) of drifts of the $F2$ region obtained by the spaced receiver method over a period of 16 months during February 1956 to May 1958 are utilized. The observations were made at 0900, 1200 and 1500 hr. I.S.T. on most of the days during this period. The operating frequency is adjusted in the range 5·8–6·2 Mc./sec., so as to obtain reflexions from an equivalent height of about 300 km. On some of the days for which 24-hourly observations are available, the mean of the three observations around these particular three hours is taken to give smoothed and representative values for these hours. As an index of magnetic activity, the magnetic K indices published by the Alibag Magnetic Observatory are utilized for this study. At first the observations for all the three hours are grouped together and the speeds of drift corresponding to each value of K indices are sorted out and averaged. Fig. 1 shows a plot of the average speeds of drift thus obtained against the corresponding K indices. A total number of 466 observations were utilized for plotting this graph. A mean straight line drawn through all the points gives best fit, and reveals the interesting feature of decrease of mean drift speed of the $F2$ region with increase of magnetic activity in the range of 0–6, a result which is contrary to the exactly opposite conclusion drawn from high-latitude observations. A further interesting point is the more or less linear decrease of drift speed with magnetic K index. As the diurnal variation study of speed of drift at this station showed variations of speed of drift from hour to hour with maxima at noon and midnight, the results for each of the above three hours is also plotted separately against the K indices and the same trend of decrease of speed of drift with increase of K index is observed, the effect being, however, less for observations at 1500 hr.

Among the previous investigators, Briggs and Spencer[2] reported a progressive increase of speed of drift with K index for the range of values above 4, and Chapman[3] observed a linear variation of speed of drift with K index in the range of 1–4 and a more rapid variation above $K = 4$. The radio-astronomy results[4], on the other hand, indicated a more pronounced effect, and presumably these results refer to a height of 500 km. In the light of these earlier results, the present observations show an unusual behaviour which seems to be characteristic of low-latitude stations. In one respect, however, our results agree fairly well with the Cambridge results. Briggs and Spencer reported that the N.S. component is more or less unaffected by K index for the low range, while the E.W. component shows an increase on the western side. In the present investigation also, we noticed that the N.S. component remains more or less steady, while the E.W. component, which is towards west, decreases until it almost reaches very low values for high K indices.

A detailed account of this investigation will shortly be published elsewhere. We are indebted to the

Council of Scientific and Industrial Research (India) for supporting this investigation.

B. RAMACHANDRA RAO
E. BHAGIRATHA RAO
Y. V. RAMANA MURTY

Ionospheric Research Laboratories,
Physics Department,
Andhra University, Waltair.

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Bose–Einstein Statistics and Helium Films

FOLLOWING the proposal of London[1] that the peculiar transition in liquid helium may be due to the accumulation of a significant fraction of the total number of particles in the ground-state of a Bose–Einstein gaseous assembly, many attempts have been made to understand the behaviour of this liquid in terms of the quantum statistics of a Bose gas. Most of these investigations have been confined to the study of helium in bulk. A few years ago, Osborne[2] applied Bose–Einstein statistics to helium films and showed that for films thicker than about 10^{-7} cm., the transition temperature should be the same as that for bulk liquid, whereas films thinner than this are effectively two-dimensional and should have transition temperatures much lower than the bulk value. The monotonic lowering of the 'onset' temperature of superfluidity with decreasing film thickness, observed in the study of unsaturated helium films[3] (which are essentially three-dimensional), thus remained unexplained[4].

Since it is to be expected that the properties of a statistical assembly would be modified when at least one of its dimensions becomes comparable with the mean de Broglie wave-length of the particles, we believe that a proper analysis based upon the Bose–Einstein statistics should be able to explain the observed phenomenon. In the present communication it is shown that such a study is possible provided the eigenfunctions in the bounded continuum are enumerated more exactly than is ordinarily done. We have therefore calculated the total number of particles in an ideal Bose–Einstein gaseous assembly by the equation:

$$N = \sum_i \frac{g_i}{\exp(\alpha + \varepsilon_i/kT) - 1} \tag{1}$$

and while replacing the summation over states by an integral we use the expression[5]:

$$g(\varepsilon)\,\mathrm{d}\varepsilon = 2\pi V\left(\frac{2m}{h^2}\right)^{3/2} \varepsilon^{1/2}\left[1 + \frac{S}{8V}\left(\frac{h^2}{2m}\right)^{1/2} \frac{1}{\varepsilon^{1/2}}\right]\mathrm{d}\varepsilon \tag{2}$$

We have taken periodic boundary conditions, and S/V is the ratio of the surface area of the enclosure to its volume.

Now, for the degenerate case ($\alpha = 0$) the integral over the correction term in (2) diverges. This is because we have replaced the summation by integration. On physical grounds we should expect that, to a crude approximation, the final result should not be much different from the one calculated from (2) if we replace $\varepsilon^{1/2}$ in the correction term by its average value:

$$\overline{\varepsilon^{1/2}} = (kT)^{1/2}\,[\Gamma 2\zeta(2)]/[\Gamma 3/2\zeta(3/2)]$$

whence one gets at the transition temperature T_0:

$$N = V\left(\frac{2\pi mkT_0}{h^2}\right)^{3/2} \zeta(3/2)\left[1 + \frac{0{\cdot}176\,S}{V}\left(\frac{h^2}{2mkT_0}\right)^{1/2}\right] \tag{3}$$

For a cuboid the thickness t of which is much smaller than the other two sides, we have $S/V \simeq 2/t$. Expressing t in terms of the mean de Broglie wave-length, $h\,.\,(2mkT_0)^{-1/2}$, and T_0 as a fraction r of $T_0{}^*$ (the transition temperature for an infinitely large assembly, $S/V \rightarrow 0$), we may write:

$$1 = r^{3/2}[1 + 0{\cdot}352/t] \tag{4}$$

Equation (4) gives the variation of the transition temperature with the film thickness, as shown in Fig. 1. This is in good qualitative agreement with the experimental results of Long and Meyer[3].

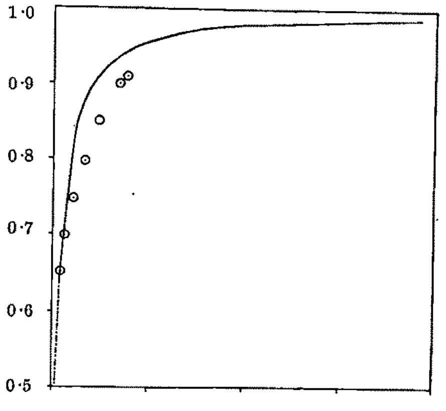

Fig. 1. The onset temperature of superfluidity T_0 (expressed as a fraction r of the transition temperature for bulk) as a function of film thickness t (in units of the mean de Broglie wave-length of the particles). ——, Theoretical curve; ⊙, experimental points of Long and Meyer

It may be noted here that the effect of the decreasing film thickness becomes important when it approaches about ten times the mean de Broglie wave-length. Further, it may be mentioned that the correction term in (4) becomes equal to unity for $t = 0{\cdot}352$, which implies a film of thickness 3·9 A. This limiting thickness is very close to the atomic distance in helium, which means that the three-dimensional approach, modified as above in order to include the effect of the surface term, is valid for films of thickness down to one atomic distance, below which the problem becomes two-dimensional and ceases to remain of practical interest.

A more detailed investigation along these lines, taking into account the interactions in the assembly, is in progress and will be reported elsewhere.

We wish to thank Prof. D. S. Kothari for suggesting this approach and for helpful discussions.

A. D. SINGH
R. K. PATHRIA

Department of Physics,
University of Delhi.

Oct. 13.

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Effects of Arc Stage of Electrical Discharge on Ignition of Inflammable Gas

There is at present no generally accepted criterion of spark ignition. A widely held view is that energy delivered to the gas is the main criterion. Kravchenko[1] has advanced the thesis that the energy in the arc stage of the discharge is the sole criterion, and that other discharge conditions, such as glow, are incapable of giving rise to ignition. During the course of investigation on inductive break-spark ignitions, a number of records of current and voltage across the discharge were taken with high-speed oscilloscopes. A current of 185 m.amp. was interrupted in a 95-mH. inductance series circuit, and the resulting discharge was made to take place in an explosive mixture of 8·3 per cent methane in air. Oscillographic studies of similar discharges in air have been made by Nethercot and Rehfisch[2], with lower time-base sweep-speeds and non-simultaneous recording of current and voltage.

The patterns of arc, glow and multiple spark were found to be similar in the explosive mixture and in air. In general, most records showed arc stages lasting up to some 30 μsec. However, a number of records were obtained where a recognizable arc stage was limited to a few microseconds as in Fig. 1, or was non-existent as in Fig. 2, and these gave normal ignitions in an 8·3 per cent mixture of methane in air. To resolve detail in the multiple breakdowns shown in the records, simultaneous voltage and current recordings were taken at a time-base speed of 0·1 μsec./cm. Fig. 3 shows such a voltage record and Fig. 4 a corresponding current record, taken under conditions identical with those in Figs. 1 and 2. It is seen that nowhere is there a characteristic arc step; the wave carrying a superimposed high-frequency oscillation is likely to be due to the local oscillatory circuit at the contacts. A detailed examination of a number of records has shown that arcs are established at the two levels of 96 and 144 V. and glows at 384 V. It is therefore clear that ignition is not dependent on the arc stage of the discharge.

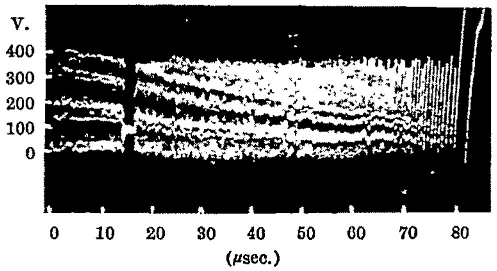

Fig. 1

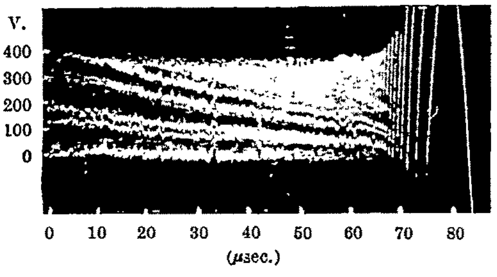

Fig. 2

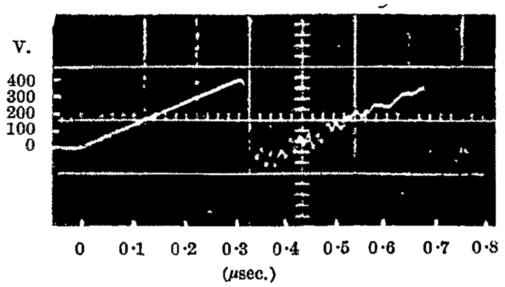

Fig. 3

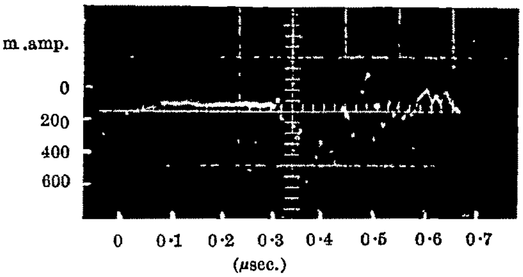

Fig. 4

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I. Berz

Mining Research Establishment,
Worton Hall,
Isleworth, Middlesex.

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We agree entirely with Mr. Berz that an arc discharge is not essential for the ignition of inflammable gas, but we cannot agree with his statement that the multiple breakdowns shown in his records have none of the characteristics of an arc discharge. We suggest that they are transient arcs of very short duration in which the current is relatively constant as is the voltage, although its value is appreciably greater than that in a sustained discharge.

Multiple discharges, which often occur when inductive circuits are broken, are due to the capacitance associated with the circuit inductance and the opening contacts. At current break this capacitance is charged up at a rate which is dependent primarily on the values of the capacitance and the inductance. For short times the rate of rise of voltage is linear and the charging current is constant, as shown in the oscillograms of Figs. 3 and 4 of Mr. Berz's communication. When the voltage reaches the breakdown voltage of the gap, in this case about 400 V., the capacitive energy $\frac{1}{2}CV^2$ is rapidly discharged through the gap by the establishment of a short transient arc. The capacitance is then recharged through the inductance and the cycle is repeated until the breakdown voltage of the gap rises with increasing gap-width to a value which is greater than the peak value of the open-circuit oscillation.

From the results provided by Mr. Berz's oscillograms it is possible to deduce that the capacitance in his circuit is about 100 pF., and also that the voltage during the short discharge is about 130 V., which is in reasonable agreement with one of the values he has found for the establishment of an arc. The energy dissipated in each of these short arcs is about 8 microjoules, so that several hundred of them, as shown in the oscillograms of Figs. 1 and 2, are needed to give the total energy of a millijoule or so which is required for the ignition of a methane/air mixture under these conditions.

W. NETHERCOT
H. G. RIDDLESTONE
Electrical Research Association,
Leatherhead, Surrey.

A Source of Natural Tin Whiskers

SOME years ago, when metal whiskers were discovered growing on plated surfaces in electrical transmission apparatus[1], many investigators began searching for places where natural whiskers might be found essentially undisturbed for many years. A brief reflexion will indicate that such places are not common. Even in museums, articles are cleaned periodically so that natural whiskers which might be on their surfaces are removed.

As a collector of military small arms and accessories, I chanced to discover an excellent source of tin whiskers in almost every German bayonet scabbard from the period before the First World War to the Second World War. The steel retainer springs which hold the bayonet in the steel scabbard were coated with tin to resist corrosion. One has only to remove these springs to observe a lush growth of natural tin whiskers on their surfaces. Fig. 1 shows such a growth on springs from a German bayonet scabbard of the First World War. Growth of whiskers is not entirely general over the free surface of the springs, but appears to be confined mainly to certain areas of relatively high activity. These areas may comprise as much as 80 per cent of the free surface. Patchy growth probably results from an uneven thickness of the tin coating. Such a variation of growth of whiskers with coating thickness has been established by experiment[1]. Retainer springs of the Second World War exhibit similar patterns of incidence of whiskers on their surfaces.

Under high magnification, the whiskers appear to have round or elliptical cross-sections and their surfaces are quite clean and reflective. They exhibit a variety of habits, including straight spires, coiled filaments, kinked spires, and branched whiskers, with the majority being straight. Whiskers from the First World War period commonly reach 5 mm. in length, a few being as long as 12 mm. It is clear from the geometry of the bayonet scabbard that the 12-mm. whiskers, which are about 1μ in diameter, must have grown along the inside wall of the scabbard. However, they are not generally kinked. As expected, much shorter whiskers, having a maximum length of about 2 mm., were noted on the Second World War springs. The variation in diameters between individual whiskers from both First and Second World War springs was 1–10μ.

One of the difficulties with tin whiskers has been the scarcity of specimens of sufficient length for experimental investigation. However, whiskers from the First World War bayonet scabbard springs are quite adequate for most types of testing, and they are plentiful. Undoubtedly, many other sources of long tin whiskers exist, such as the inside surfaces of old tin-coated canteens and cartridge boxes.

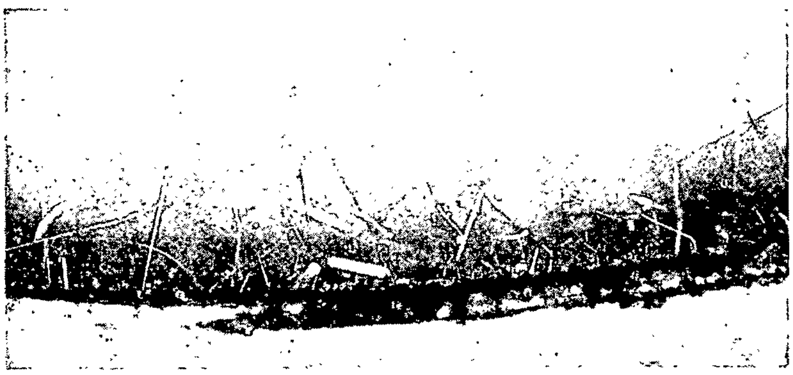

Fig. 1. Tin whiskers on First World War bayonet retainer spring

MALCOLM J. FRASER
Metals Joining Section,
Metallurgy Department,
Westinghouse Research Laboratories,
Pittsburgh 35, Pennsylvania.
Jan. 23.

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Structure of Kish and Other Graphites

FRANKLIN[1] assumed that there were only two types of layer in graphitic carbons: parallel and oriented and parallel but disoriented layers. The disoriented layers occur randomly with a probability p, between the oriented layers. From this assumption she obtained a simple formula for the intensity curve in reciprocal space:

$$I = (1 - U^2)/(1 + U^2 - 2U \cos \pi l)$$

where l is the crystallographic index and $U = 1 - p$. This is a special case of the more general intensity formula for X-rays scattered from disordered layer lattices[2,3]. All Franklin's intensity curves of the $11\bar{2}2$ line, obtained with graphitized carbons heated to between 1,720° and 3,000° C., are very close to the theoretical curves, estimated p values ranging from 0·9 to 0·1. Bacon[4] showed that the formula was also applicable to well-crystallized graphites, such as Ceylon graphite, and to three artificial samples.

Kish and flake graphite extracted from grey cast irons[5] were studied similarly. A 24-cm. Debye–Scherrer camera with a thermostat device was used. For the 0008 and $11\bar{2}2$ lines nickel $K\alpha_1$ (θ, 81°) and chromium $K\alpha_1$ (θ, 82°) radiations were used respectively. For the 0008 line pressed specimens 0·7 mm. thick and 6 mm. in diameter were used in order to concentrate the scattering on the $000l$ lines. For the $11\bar{2}2$ line ordinary rod specimens, diameter 0·7 mm., were used.

The separation of the α_1 line from the $\alpha_1\alpha_2$ doublet and the corrections for the geometrical broadening were carried out by Bracewell's method[6]. In evaluating numerically the integral equation, the geometrical broadening was assumed to be given by the profile of the $11\bar{2}0$ line.

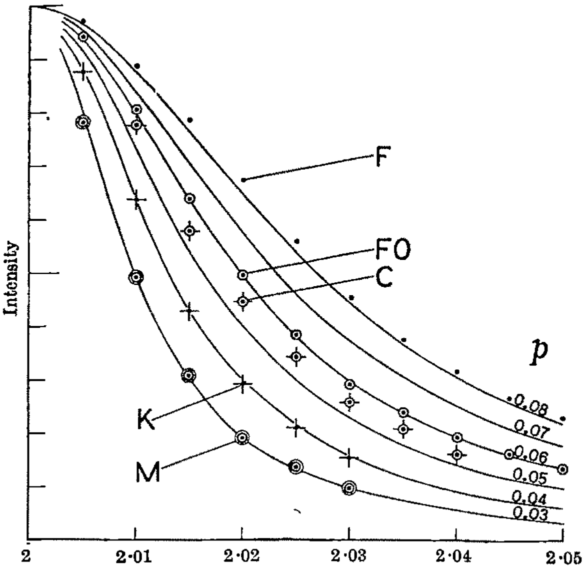

Fig. 1. The intensity distribution in reciprocal space derived from the powder line $11\bar{2}2$ of various graphites

The theoretical intensity curves for the $11\bar{2}2$ line in reciprocal space are shown in Fig. 1. The observed points *F*, *FO*, *C*, *K* and *M* were determined from microphotometer records obtained with the following samples: (*F*) Flake graphite extracted from grey cast iron, used in a previous study[5]. (*FO*) The same sample of flake graphite wet-oxidized for 12 hr. as previously described[5]. After the treatment *p* decreased from 0·082 to 0·060. (*C*) Ceylon graphite ground in an agate mortar after mixing the sample with small amounts of rock salt and treating the mixture with hydrochloric and hydrofluoric acids. The grain-size was 0·01–0·1 mm.; *p* was estimated to be 0·055, whereas Bacon's result was 0·050. A slight increase in the proportion of disordered layers was presumably caused by the grinding. (*K*) Kish graphite obtained from the Kamaishi mine, Japan. The sample was neither mechanically nor chemically treated. When it was examined under a microscope well-crystallized pure flakes with flat surfaces were observed. The grain size was 0·1–0·7 mm. Recently, Walker[7] found smaller interplanar distances than normal in untreated Kish containing 48 per cent ash. He attributed this to internal pressures produced when the Kish was formed from molten iron. In my sample no contraction of spacings greater than 0·0001 A., as compared with the Ceylon graphite, was observed. (*M*) Original flakes of Madagascar graphite. The grain size was 0·4–0·8 mm.

As will be readily seen from Fig. 1, the agreement between the observed points and the theoretical curves is striking.

EITARO MATUYAMA

Faculty of Engineering,
Yamaguchi University,
Ube, Japan.
Nov. 11.

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Surface Charges produced on Insulators by Short- and Long-time Ionization

WITH the use of a rotating-probe electrometer[1], high-resolution measurements of induced surface charges have revealed some significant charge differences between short- and long-time periods of ionization. This difference may lead to a better understanding of the mechanism of dielectric failure in the presence of gaseous ionization.

The induced voltage charge pattern on the surface of polyethylene, as measured with the rotating probe electrometer immediately after a d.c. discharge at the inception voltage of a 1-mm. uniform field gap, is shown in the oscillograph trace drawing No. I (Fig. 1). The charge pattern measured a month later is essentially the same as shown in trace No. II (Fig. 1). These patterns show that the polarity of the charge is the polarity of the electrode facing the dielectric surface, that the magnitude of charge is uniform, and that it remains virtually unchanged at normal room conditions for a long period of time.

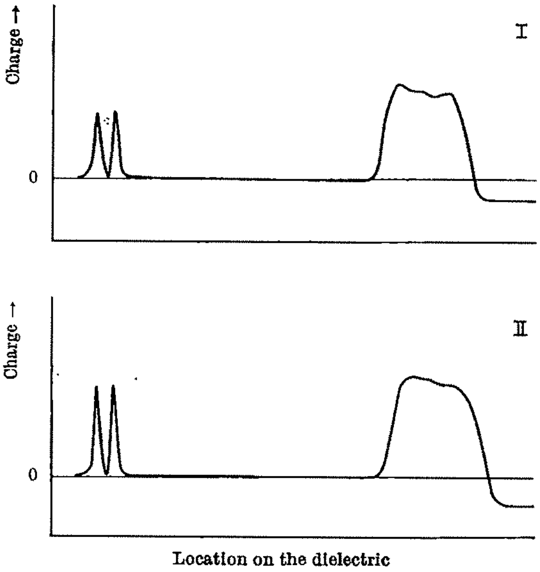

Fig. 1. Positive charge patterns on polyethylene after d.c. discharge (I) and one month later (II)

As shown by Mason[2], if the polarity of the field is reversed, the influence of such a charge could reduce the inception voltage of the gap by as much as 50 per cent. In this case the influence of the charge could be effective a month after its inception. In all these charge measurements marker pips on the left side of the cathode-ray oscilloscope trace are obtained from two wires (0·25 diam.) mounted vertically in plastic 3·5 mm. apart and maintained at a d.c. potential of + 500 volts above ground. The rotating probe picks up an induced voltage from these wires as it passes over the wires and the charged surface. In this manner the magnitude and charge diameter can be determined by measuring the width of the charge pattern at the points of inflexion.

Short-duration 60-cycle ionization tests were made between two parallel polyester resin surfaces separated by 1 mm. A potential of 5·6 kVp. was applied for $1\frac{1}{2}$ cycles.

The charge on both surfaces was then measured at the discharge site. The cathode-ray oscilloscope trace drawings are shown in Fig. 2. The positive charge

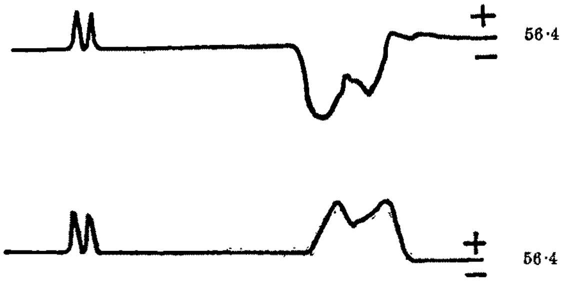

Fig. 2. Charge pattern on opposed surfaces of polyester resin after breakdown at 60 c./s.

on one surface is accompanied by a negative charge on the opposite surface. The charge patterns are not as uniform as obtained from the single discharge shown in Fig. 1. This is probably caused by some neutralization of charge during the polarity reversals; however, the polarity is still essentially determined by the polarity of the opposite electrode at the last half-cycle.

For an ionization test of long duration a stainless-steel electrode (2·54 cm. diam.) of 0·318 cm. radius was used to form a uniform 1-mm. gap to a polyester resin surface. Ionization tests were run at an a.c. voltage of 5·6 kVp. for 27 hr. The sample was removed from test and the charge pattern was obtained two days later as shown in Fig. 3. The charge trace obtained with the rotating probe shows that the charge polarity is no longer determined by the polarity of the last voltage-cycle; but we find small areas of both high positive and negative charge side by side. Furthermore, the charges are not easily removed as in the case of the short-duration induced charges of Figs. 1 and 2. This is readily accomplished by breathing moist air on the surface or by radiation with polonium, in spite of the fact that short-duration induced charges remain over long periods of time under normal conditions.

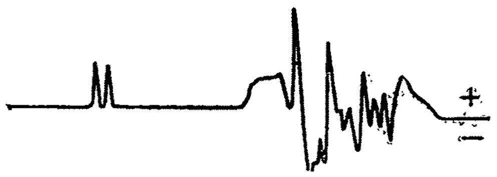

Fig. 3. Charge pattern on polyester resin after a.c. discharge for 27 hr.

It is known that the longer period of ionization results in the breaking of molecular bonds of the polyester resin; but it was not expected that this would result in large differences in charge polarity. On the contrary, it was anticipated that this would result in smoothing out the charges due to the increased surface conduction which is known to occur.

It is believed that longer periods of ionization result in higher energy discharges at selective sites which induce electrons to penetrate deeper into the dielectric, and that this accounts for the high positive and negative charges which occur close to each other and most probably indicate the site where selective erosion occurs. Thomas[3] concluded that negative discharges cause electrons to penetrate into the surface of the dielectric, where they are strongly bound and not easily reached by positive ions. It would appear from the foregoing measurements, made possible by the high resolution of the rotating probe, that there is some support for his conclusions.

STANLEY I. REYNOLDS
General Electric Research Laboratory,
Schenectady,
New York.
Jan. 13.

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CHEMISTRY

Synthesis of Colour Centres in Silica and their Thermoluminescence

THE colour centre which is responsible for the colour of smoky quartz has been described by O'Brien[1]. The precursor depends upon an aluminium ion substituted for silicon with an associated interstitial lithium ion for charge compensation. The centre consists of a hole trapped in the vicinity of the substitutional aluminium, the lithium having trapped an electron and migrated from the scene. We have now found that combinations of other ions with aluminium in silica powder produce an analogous centre under γ-radiation and have investigated the thermoluminescence of the pure and doped powders after exposure to γ-radiation.

The silica powder was doped by wetting it with solutions of the impurities and heating to 1,500° C. The undoped powder remained colourless after exposure to 10^6 r. γ-radiation from cobalt-60. Powder doped with 0·01 aluminium plus 0·01 lithium became a deep bluish-purple with the same dose. Samples doped with aluminium alone remained colourless after exposure. Cohen[2] showed by his measurements of anisotropy of the absorption that the aluminium must be substitutional. Substitution of aluminium for silicon ion requires charge compensation by a second ion such as that of lithium.

In several experiments lithium was replaced by other ions selected to supply the excess positive charge without necessarily supplying electron traps. Silver, magnesium and phosphorus, when added in combination with aluminium, produced coloration under radiation. Silver may be considered to have an action similar to lithium in being present interstitially and in providing an electron trap. Phosphorus, on the other hand, should be considered substitutional because of its high charge and normal four-fold co-ordination with oxygen. Magnesium must be considered intermediate. These experiments allow us to generalize the impurity centre described by O'Brien.

The undoped silica powder which showed no coloration after exposure had a very intense thermoluminescence with a maximum at about 280° C. when heated at 4 deg. C./min. The exposed silica (aluminium, lithium) showed luminescence maxima in the same region but with lower intensities. The luminescence of silica (0·01 aluminium, 0·01 lithium) was measured for several dose-levels. Although the coloration in these samples increased with dose, the integrated thermoluminescence went through a maximum. The luminescence of the pure silica sample was considered due to a process in which interstitial oxygens plus trapped holes are annihilated with oxygen vacancies plus trapped electrons; Mitchell and Paige[3] had proposed such centres, corresponding to two absorption bands in the ultra-violet region. The quenching of the luminescence of the aluminium centres is evidence for the interaction of these and the ultra-violet absorbing centres. The probability of the interaction would be expected to increase as the concentrations increased and therefore the luminescence showed a maximum at an intermediate dose.

Lithium can play a predominant part in the interaction of these centres while bleaching. The lithium in an interstitial position would be quite mobile, especially after being discharged by electron capture. Phosphorus ions, as well as lithium ions, can stabilize the aluminium in the substitutional position required in the precursor. However, the low mobility of the substitutional phosphorus in comparison with the high mobility of the discharged lithium should have a strong influence on the degree of interaction of the centre upon bleaching. It is planned to extend the investigation of thermoluminescence to silica (aluminium, phosphorus) to test this proposal, and to fused silica with controlled impurities so that the absorption bands can be studied and correlated with the luminescence.

J. R. Hensler

Bausch and Lomb Optical Co.,
Rochester 2,
New York.
Jan. 14.

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Beta-Polymorphs of Uranium and Thorium Disilicides

Thorium disilicide was first described by Brauer and Mitius[1], who isolated single crystals and reported the crystal structure to be tetragonal with the space group *I*4/*amd*. Later, Zachariasen[2] described an isostructural uranium disilicide observed initially during metallurgical examinations by Kaufmann, Cullity and Bitsianes[3]. Another phase, thought by Kaufmann *et al.* to be U_2Si_3 and also studied by Zachariasen, was found to have a hexagonal crystal structure of the AlB_2-type, space group *C*6/*mmm*. The crystal structure results led Zachariasen to suggest that this compound was a second form of uranium disilicide and he designated it β-USi_2. The tetragonal uranium and thorium disilicides accordingly became the alpha forms. More recently, Jacobson, Freeman, Tharp and Searcy[4] obtained a thorium silicide isostructural with Zachariasen's β-USi_2, but observed that the silicon content was lower than that of α-$ThSi_2$. They used the description 'β-$ThSi_2$' but suggested that the true composition was $ThSi_{1\cdot5\pm0\cdot2}$.

We have prepared all the above phases by arc-melting and have examined them by metallographic and X-ray diffraction techniques. A noticeable feature of the preparations is the formation of 'β-USi_2' and 'β-$ThSi_2$' from mixtures containing 62–63 atomic per cent silicon, compared with the 66·7 atomic per cent required for the formation of the alpha disilicides. The compositions of these so-called beta phases accordingly appear to be U_3Si_5 and Th_3Si_5. Our values for the structure cell dimensions are:

U_3Si_5: $a_0 = 3{\cdot}843 \pm 0{\cdot}001$ A.; $c_0 = 4{\cdot}069 \pm 0{\cdot}001$ A.

Th_3Si_5: $a_0 = 3{\cdot}985 \pm 0{\cdot}001$ A.; $c_0 = 4{\cdot}228 \pm 0{\cdot}001$ A.

During an investigation into reactions between the silicides of uranium and thorium and liquid bismuth, two new silicide phases have been isolated. X-ray analysis shows that they are hexagonal with space group *C*6/*mmm*. These new phases, like the above M_3Si_5 compounds, have the AlB_2-type crystal structure, but the cell dimensions are different and, in particular, the axial ratio $c/a < 1$ compared with $c/a > 1$ for the M_3Si_5 compounds.

Heat treatment of the new thorium–silicon compound in the temperature-range 1,200–1,300° C. transforms it into α-$ThSi_2$, while heat treatment of α-$ThSi_2$ at 850° C. yields the new thorium–silicon phase. It is clear that this compound is in fact the true β-$ThSi_2$ and the analogous uranium compound the true β-USi_2. The structure cell dimensions obtained from X-ray diffraction results are:

β-USi_2: $a_0 = 4{\cdot}028 \pm 0{\cdot}001$ A.; $c_0 = 3{\cdot}852 \pm 0{\cdot}001$ A.

β-$ThSi_2$: $a_0 = 4{\cdot}136 \pm 0{\cdot}001$ A.; $c_0 = 4{\cdot}126 \pm 0{\cdot}001$ A.

Structural characteristics and structure-cell dimensions of the alpha and new beta polymorphs have been compared and a mechanism has been deduced to explain the structure transformation. Furthermore, it appears probable that the atomic arrangements of the M_3Si_5 structure can be derived from that of the β-structure by omission of one-sixth of the silicon atoms. As a consequence, the axial ratio changes from a value less than unity in the beta structure to a value greater than unity in the M_3Si_5 structure.

A more complete and detailed account of the work outlined above is in preparation.

A. Brown
J. J. Norreys

Research Laboratories,
The General Electric Co., Ltd.,
Wembley, Middlesex.
Jan. 26.

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Effect of the Carrier Gas on the Sensitivity of a Thermal-conductivity Detector in Gas Chromatography

In a recent communication[1], the sensitivity, dt/dx, of a thermal-conductivity cell to small amounts of organic vapours was derived from:

$$t_1 - t_0 = a/K_1 \qquad (1)$$

where t_1 and t_0 are the temperatures of the hot wire and body of the cell respectively, a is constant, and K_1 is the thermal conductivity of the carrier gas. The sensitivity was then shown to be:

$$\frac{dt}{dx} = -\frac{a(K_1 - K_2)}{K_1^2}, \text{ approximately} \qquad (2)$$

where K_2 is the thermal conductivity of the organic vapour and x is its concentration in the carrier gas. From equation 2, carrier gases of low thermal conductivity would be expected to produce the highest sensitivities. However, in practice a is usually varied, and sensitivities should be compared at equal values of t_1. Carrier gases of high thermal conductivity would then give the highest sensitivities.

An expression for a can be derived from a heat-balance equation that considers only the heat loss, from the wire, due to the thermal conductivity of the gas:

$$\frac{I^2R}{J} = CK_1\,(t_1 - t_0) \qquad (3)$$

where I is the current to the hot wire, R is the resistance of the wire at t_1, J is Joule's constant, and C is a constant for a given cell that depends only on the cell geometry. Rearranging gives:

$$t_1 - t_0 = \left(\frac{I^2R}{JC}\right)\frac{1}{K_1} \qquad (4)$$

From equations 1 and 4:

$$a = \frac{I^2R}{JC} \qquad (5)$$

Therefore, any change in current (I) or voltage (IR) changes a.

In practice, when the carrier gas is changed, current or voltage is adjusted to permit operating at a high wire temperature, where sensitivity is high. To maintain this wire temperature, a must vary with the thermal conductivity of the carrier gas, as shown by equation 1. Then, a/K_1 is constant, and, by rearranging equation 2:

$$\frac{dt}{dx} = \frac{a}{K_1}\left(1 - \frac{K_2}{K_1}\right) \qquad (6)$$

In this case, sensitivity will depend on the factor, $1 - \frac{K_2}{K_1}$; which is largest for the highest value of K_1. For this reason, gases of high thermal conductivity, such as hydrogen or helium, are preferred for maximum sensitivity in the detection of organic vapours.

The increase in cell sensitivity with carrier-gas thermal conductivity has been confirmed by measuring the output voltages developed with prepared mixtures of hydrocarbons or methanol in helium or nitrogen. Table 1 shows the voltages obtained at two levels of cell and wire temperature.

Table 1. EFFECT OF CARRIER GAS ON OUTPUT

° C. t_1	t_0	Vapour	Output, millivolts for 1 mole per cent vapour in: Helium	Nitrogen
100	25	*n*-hexane	21·2	2·20
100	25	methanol	11·0	0·45
200	150	benzene	9·9	0·29
200	150	*cyclo*hexane	10·8	0·20
200	150	*n*-hexane	11·5	0·23

Studies under way in our laboratories will illustrate further disadvantages of using carrier gases of low thermal conductivity.

L. J. SCHMAUCH
R. A. DINERSTEIN

Research and Development Department,
Standard Oil Company (Indiana),
Whiting, Indiana. Jan. 23.

Ray, N. H., *Nature*, **182**, 1663 (1958).

IT is quite true that the sensitivity of the detector would be higher with a carrier gas of high thermal conductivity, provided that the hot wire can be maintained at the same temperature. In practice, however, it is not always possible to achieve this because the bridge supply voltage is generally fixed by the makers of the instrument at a level which permits safe operation with a gas of low conductivity, and to increase the bridge voltage may necessitate modification to the electrical circuit of the instrument.

There is a further advantage with a carrier gas of low thermal conductivity; the thermal conductivities of organic gases increase more rapidly with temperature than those of monatomic gases such as argon and helium, so that if the operating temperature is raised the thermal conductivity difference, and hence the sensitivity, increases if a carrier of low conductivity is used; whereas with helium the reverse is the case, as shown in Table 1 of Dr. Dinerstein's communication.

N. H. RAY

Research Department,
Alkali Division,
Imperial Chemical Industries, Ltd.,
Winnington, Northwich.

Separation of Strontium-90 from Calcium

ONE of the main difficulties in determining the strontium-90 content of biological materials such as milk, bone and coral is the separation of strontium from the large amounts of calcium which accompany it. In an endeavour to avoid the rather tedious and time-consuming method based on the insolubility of strontium salts in strong nitric acid[1], various ion-exchange methods have been developed[2-5] in which the alkaline earth ions have first been absorbed on to a cation exchange resin and then successively eluted by agents such as lactate and citrate at a controlled *p*H. Although the amount of strontium in such samples is very small, these methods require the use of a relatively large column of sufficient exchange capacity to absorb at least part of the accompanying calcium as well as the strontium.

In view of the differing stability constants of the calcium and strontium ethylenediamine tetraacetic acid complexes (log $K_{1\mathrm{Sr}} = 8{\cdot}63$, log $K_{1\mathrm{Ca}} = 11{\cdot}0$)[6], a study was made of the absorption of these elements by a cation exchange resin, 'Zeo-Karb 225', in the presence of ethylenediamine tetraacetic acid over the *p*H-range 3–7. In each experiment 25 mgm. of strontium or calcium ions and 1 gm. of disodium ethylenediamine tetraacetic acid were used with a 10-ml. resin column (0·9 cm. internal diam.) in the sodium

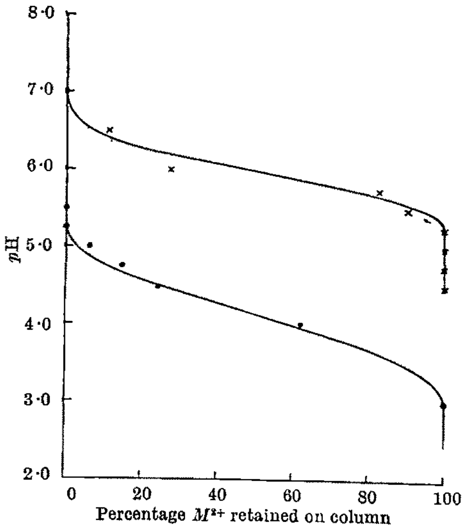

Fig. 1. Effect of *p*H on the removal of strontium (×) and calcium (●) from a solution of ethylenediamine tetraacetic acid by 'Zeo-Karb 225' cation-exchange resin column

form. It is seen from Fig. 1 that at *p*H 5·25, strontium, present in the cationic form, is quantitatively retained on the resin, while calcium is complexed by the ethylenediamine tetraacetic acid and passes through.

These results were confirmed by using the method to separate strontium from prepared strontium–calcium mixtures to which had been added calcium-45 as tracer. The recovery of strontium was checked by eluting the resin with 3 *N* hydrochloric acid and precipitating the strontium as carbonate and weighing. The activity of the carbonate precipitate gave a measure of the degree of contamination of the strontium with calcium. This was shown to be less than 1 per cent.

This ion-exchange recovery of strontium from strontium–calcium mixtures is achieved with the use of very small columns, and should be capable of application to the simple determination of strontium-90 on a routine basis, considerably reducing the time required for each determination.

I wish to acknowledge the assistance of Miss M. Barnett with the experimental work.

P. S. Davis

Australian Atomic Energy Commission,
Research Establishment, Lucas Heights,
New South Wales. Jan. 21.

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Detection of Keto-Acids

Most of the reported chromatographic work on the identification of keto-acids has involved the paper chromatography of a derivative, usually the 2,4-dinitrophenylhydrazone. A simple technique has been developed in this Laboratory whereby acidic materials which may contain keto-acids are chromatographed directly on Whatman No. 1 paper using a solvent containing ethyl acetate/acetic acid/water (60 : 25 : 15 v/v). After irrigation and drying, the papers are sprayed with a saturated alcoholic solution of 2,4-dinitrophenylhydrazine, dried with hot air for 5 min., and then sprayed with an approximately 5 per cent solution of potassium hydroxide in 90 per cent ethanol. The 2,4-dinitrophenylhydrazones which have been formed *in situ* react to give a variety of colours against an almost colourless background. In general, the derivatives of α-dicarbonyl compounds give colours ranging from light blue to dark purple. Derivatives of other carbonyl compounds produce yellow, red or brown spots. The colour given by any one of these derivatives is often distinctive for that compound, and may sometimes serve to differentiate between keto-acids with similar R_F values.

This method has proved useful recently in work on the ozonization of aqueous solutions of simple aliphatic acids, when mesoxalic acid may be produced. The oxidation products are chromatographed using a method developed here in which a *p*H indicator is incorporated in the solvent[1]. Mesoxalic acid or other keto-acids may have R_F values similar to those of other non-ketonic acids, and accordingly a second chromatogram without *p*H indicator is run and treated in the way described.

As little as 5 μgm. mesoxalic acid can readily be detected by this method.

F. Dobinson

Coal Constitution Laboratory,
Department of Mining,
University of Birmingham.
Jan. 30.

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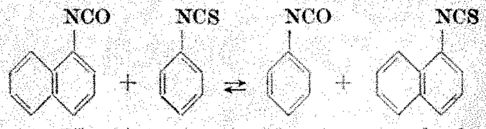
Equilibration of *iso*Cyanates and *iso*Thiocyanates

*iso*Thiocyanates have been prepared by several methods[1-4]; I have recently found that they can also be prepared conveniently by the equilibration of *iso*cyanate and *iso*thiocyanate groups. This equilibration occurs slowly at elevated temperatures and appears to be generally applicable to the preparation of *iso*thiocyanates and mixed *iso*cyanates–*iso*thiocyanates.

The reaction is illustrated by the following equation for the preparation of naphthyl *iso*thiocyanate :



This equilibration reaction may proceed through dimer formation. The yields obtained are fair, and considerable residue is formed. Decomposition leading to tar formation may be caused by the prolonged time at considerably elevated temperature required to establish equilibrium. Further study of the reaction and its variables, particularly acceleration of equilibrium formation by catalytic action, might greatly improve the yields.

25 gm. α-naphthyl *iso*cyanate (Matheson, Coleman and Bell) and 21 gm. phenyl *iso*thiocyanate (Matheson, Coleman and Bell) were mixed and heated, with stirring, under reflux at a pot temperature of 215–225° C. for 14 hr. During this period the reaction mixture turned yellow and gradually dark brown. Distillation of the reaction mixture yielded four fractions : 12·3 gm. distillate boiling at 164–168° C. at atmospheric pressure ; 4·5 gm. distillate boiling at 44–46° C. at 2–3 mm. mercury ; 3·4 gm. distillate boiling at 85–90° C. at 1–2 mm. mercury ; 13·6 gm. material boiling at 109–111° C. at 1 mm. mercury. This last fraction solidified on cooling to room temperature. A dark brown tarry residue (8·2 gm.) was left in the reaction flask. The solid material (m.p. 46–54° C.) was dissolved in toluene, the small amount of insoluble material filtered off and the toluene stripped off. The resulting white solid, α-naphthyl *iso*thiocyanate, weighed 12·8 gm. and melted at 56·7–57·5° C.

p-Bromophenyl *iso*thiocyanate (m.p. 61·6–62·0° C.) was prepared by an identical procedure in 35 per cent yield.

L. C. Case

Chemical Engineering Department,
Purdue University,
Lafayette, Indiana.
Jan. 10.

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Structure of Malvalic Acid and Some Related C_{18} and C_{19} *Cyclo*propane Fatty Acids

In recent years an interesting group of fatty acids containing a *cyclo*propane or a *cyclo*propene ring has been isolated from natural products or synthesized. This work followed the discovery by Hofmann *et al.*[1,2] of a biologically active $C_{19}H_{36}O_2$ *cyclo*propane fatty acid, lactobacillic acid, in the lipides of *Lactobacillus arabinosus* and *L. casei*. Four more C_{19} acids of this type were synthesized[3,4]—the DL, *cis* and *trans*, 9-10 and 11-12, methylene octadecanoic acids. The crystal structures of two of these racemates have been studied[5,6], namely, the DL *trans* 9-10 and DL *cis* 11-12, and shown to have the characteristic straight- and bent-chain configurations illustrated in the electron density Fourier projections in Figs. 1 and 2. From the similarity in the diffraction data, the other two racemates are believed to be structurally isomorphous[7] in the *trans* and *cis* series, respectively. Of these, the DL *cis* 9-10 acid was shown[7] to be identical with the dihydrosterculic acid obtained[4] by hydrogenation of the sterculic acid[8], $C_{19}H_{34}O_2$, from the kernel oil of the tropical tree *Sterculia foetida*.

Lactobacillic acid itself had previously been identified with the phytomonic acid from the lipides of the plant pathogen *Agrobacterium* (*Phytomonas*) *tumefaciens*) which was studied earlier[9,10] but not recognized as a *cyclo*propane acid. From chemical and crystallographic evidence[11] it is now considered to be D or L *cis* 11-12 methylene octadecanoic acid, but this has yet to be completely confirmed by chemical synthesis or single-crystal structure analysis.

More recently, two C_{18} *cyclo*propane fatty acids have been reported, dihydrobombacic acid from the bombacic acid of kapok seed oil[12], and dihydromalvalic acid by hydrogenation of the malvalic acid from the leaves and seeds of *Malva verticillata* and *M. parviflora* and from cotton seed[13,14].

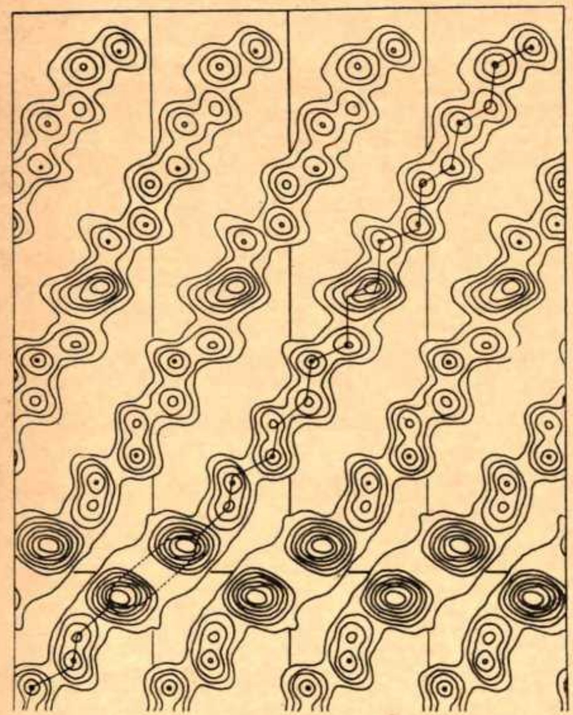


Fig. 1. DL *trans* 9-10 methylene octadecanoic acid

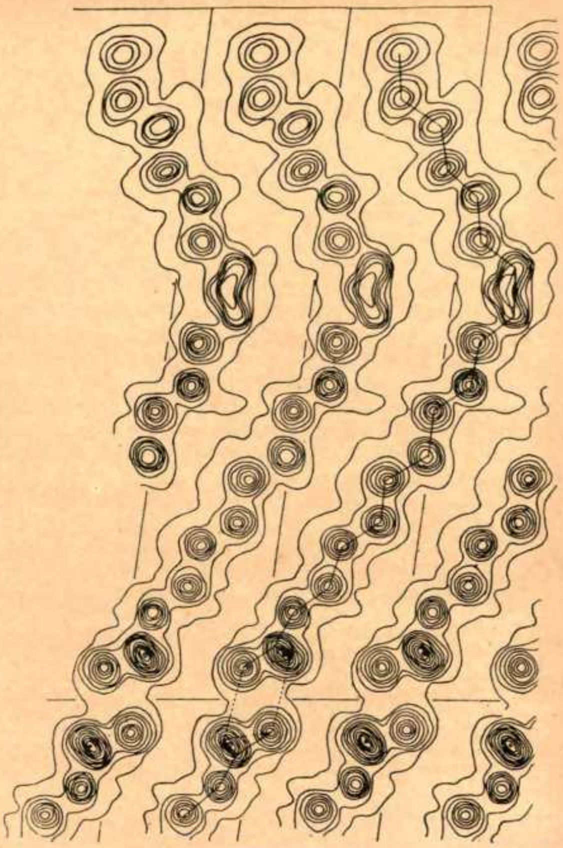
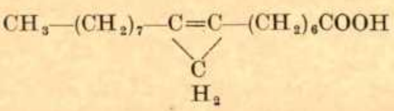


Fig. 2. DL *cis* 11-12 methylene octadecanoic acid

We have carried out a crystal structure analysis of dihydromalvalic acid and have shown it to be DL *cis* 8-9 methylene heptadecanoic acid, that is, DL-*cis*-7-(2-octa *cyclo*propyl) heptanoic acid. The molecule has a boomerang shape, as befitting its country of origin, which is well illustrated in the Fourier projection down the axis shown in Fig. 3. This stereochemistry with the bend at the *cis* substituted ring is analogous to that found in the crystal structure of the synthetic DL *cis* 11-12 methylene octadecanoic acid[6] (Fig. 2), and quite different from the straight chain structure of the DL *trans* 9-10 methylene octadecanoic acid[5] (Fig. 1). A chemical synthesis of this molecule, using the methods devised for the C_{19} acids, is now in progress (Hofmann, K., unpublished work).

If Nunn's *cyclo*propene structure for sterculic acid[8] is accepted, as against the 'conjugated structure' or the 'methylene allene' structure, as generally it appears to be[15,16], malvalic acid can now be assigned the structure (I), on the basis of the chemical and spectroscopic evidence[13,14] and our structure analysis of the dihydro derivative.



$$CH_3-(CH_2)_7-C=C-(CH_2)_6COOH \qquad (I)$$
$$\underset{H_2}{C}$$

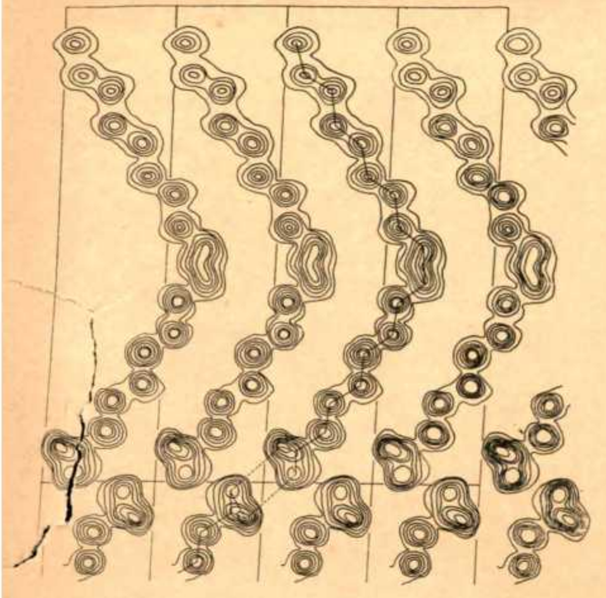


Fig. 3. Dihydromalvalic acid (DL *cis* 8-9 methylene heptadecanoic acid)

This confirmation of the natural occurrence of a C_{18} *cyclo*pentene fatty acid is of interest from the point of view of biosynthesis, since it appears to eliminate a mechanism analogous to the addition of a C_1 fragment to a naturally occurring unsaturated acid as has been proposed in the case of lactobacillic acid[17].

This research is supported by a grant (*E*-1423) from the U.S. Public Health Service, National Institutes of Health. We are grateful to Dr. Vickery, of the Commonwealth Scientific and Industrial Research Organization, Australia, for providing us with the sample of dihydromalvalic acid, and to Prof. K. Hofmann, of the Biochemistry Department of the University of Pittsburgh Medical School, for his close co-operation in our study of these acids.

B. Craven
G. A. Jeffrey

Crystallography Laboratory,
University of Pittsburgh,
Pennsylvania.

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BIOCHEMISTRY and PHYSIOLOGY

Polysaccharide Fibres in Mammalian Connective Tissue

The presence of fibres which differ chemically and physically from the contiguous collagen and elastin in mammalian and other connective tissue has been reported previously[1]. Four types of fibres were defined upon the basis of morphological variations as observed with the optical microscope and described as redimiculous, vitreous, jointed and barbed[2]. None of these exhibits hydrothermal contraction associated with collagen, and they all resist acid hydrolysis and digestion by collagenase and elastase. Mechanical deformation of individual fibres produces sharp fractures with the vitreous, jointed and barbed types, while the redimiculous variety exhibits predominantly plastic distortion. The absence of the elastic recovery associated with normal protein fibres of connective tissue, added to the other differences, indicates a molecular structure completely different from that of the fibrous proteins.

Morphologically, the redimiculous fibres are similar to cotton fibres in that they consist of helically disposed fibrils with the helix angles changing along the fibre axis as the ends taper. They have approximately the same birefringence as raw cotton and exhibit the characteristic ability to produce this at all angles to the polarized beam. The vitreous fibres show similar birefringence, but no helical fibril assemblies have been observed and there are marked differences in fibre diameters between them. They also exhibit extinction in the usual uniaxial manner. All four types show a sporadic distribution in tissue and areas of local concentration occur adjacent to zones predominantly protein, that is, collagenous. The numbers of the types present decrease in the order redimiculous–vitreous–jointed–barbed. They have not been definitely associated with any pathological changes as yet and the only correlation reported is a general increase in numbers with the age of the tissue[3].

The specimens studied have all been removed from either fresh or fixed tissue by needles, washed in distilled water, and then observed in both normal and polarized light. Recent work by Cruise and Keech (to be published shortly) has shown that when these individual fibres are ground in a conventional tissue grinder and the suspensions are examined with the electron microscope, no evidence of the 640 A. striations associated with collagen is obtained. Each of the four types produced angular quasi-crystalline units dispersed among plastic fibrous debris, suggesting that these fibres are essentially two-phase structures.

Hall *et al.*[4] have reported that a complicated acid, alkali and enzymatic digestion of bovine dermis results in a fibrous residue of what they term 'mammalian cellulose', which gives an X-ray diffraction diagram similar to that from partially oriented cotton fibres. In view of the known resistance of these polysaccharide fibres to the reagents used, it would appear that this treatment has in effect concentrated these fibres from a random distribution in the fresh dermis to a residual mass. These workers have described two types of fibres appearing in the tissue and the residue, one of which they term anisotropic, and which corresponds morphologically with the redimiculous fibres, and the other which they term

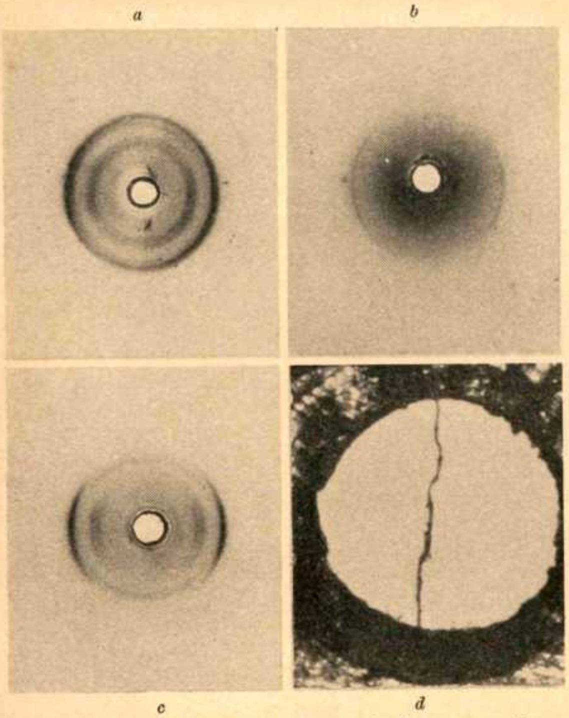

Fig. 1. *a*, *b*, and *c* are enlargements of micro-camera X-ray photographs of: *a*, a somewhat disordered bundle of redimiculous fibres running roughly parallel to the long side of the photograph; *b*, a single redimiculous fibre; *c*, a parallel bundle of cotton fibres: *d* is a photomicrograph of the specimen used for *b*, which was fastened across a hole in copper foil (actual diameter, 0·86 mm.)

a two-phase structure. This appears to be identical with a vitreous type described by Cruise[3] from human Achilles tendon. They suggest that this type is probably composed of a collagen core upon which has been deposited *in vivo* a cellulose coating. In view of the electron microscope disintegration studies of Cruise and Keech this seems doubtful, as no evidence of collagen-like constituents was observed when individual fibres were examined. With this exception there are obvious similarities between the various morphological and optical findings, and attempts were made to obtain X-ray diffraction diagrams from individual fibres to investigate their molecular structure.

Fibres were teased from tissue under the optical microscope and after identification were collected into 'typed bundles' of 5–20 fibres. These and some single fibres were mounted across 1-mm. holes in metal strips and photographed with copper $K\alpha$ radiation from an Ehrenberg–Spear fine focus X-ray tube running at 50 kV., 2 m.amp. and modified to give a focus of 1·0 mm. × 0·1 mm. Diffraction patterns were photographed with a cylindrical camera of 1·0 cm. radius.

Fig. 1 shows some of the photographs: (*a*) of a somewhat disordered bundle of animal redimiculous fibres running roughly parallel to the long side of the photograph; (*b*) of a single human redimiculous fibre; (*c*) is a photograph of a bundle of cotton fibres for comparison; (*d*) is a photomicrograph of the single fibre. The resemblance to native cellulose is very striking, and confirms that the fibres photographed by Hall *et al.*[4] had not been altered by the somewhat drastic treatment used for concentrating them and that these fibres are essentially the same in both human and animal tissue.

A bundle of vitreous fibres gave much the same photograph as (*a*); but so far no diffraction pattern has been detected from a single vitreous fibre.

A bundle of well-aligned jointed fibres, with an exposure four times that of (*a*), gave only faint indications of a diffraction pattern, having some resemblance to that of collagen, but none to cellulose. So far no photographs have been taken of barbed fibres. The investigation is continuing.

A. J. CRUISE

4 Raymead Way,
Fetcham, Surrey.

J. W. JEFFERY

Birkbeck College,
London, W.C.1.
Jan. 13.

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Incorporation of Radioactive Iron into Hæmatin a

THE rate of synthesis of hæmoproteins has been studied by measuring their incorporation of iron-59. Most of these studies have concerned hæmoglobin, but some[1,2] also myoglobin, catalase, cytochrome *c* and cytochrome b_5. No report on the incorporation of iron-59 into cytochrome oxidase has yet appeared. Except for cytochrome *c* and cytochrome oxidase, the above pigments all contain protohæm, so that measurement of their individual uptake of iron-59 requires their previous separation, which is often difficult.

In the present work, the fact that cytochrome oxidase (cytochromes $a_3 + a$) has a unique prosthetic group (hæm *a*) which we can readily separate from protohæm, facilitated the study of the synthesis of this enzyme in heart, liver and kidney of rats. Preliminary work had been carried out by D. B. Morell and A. Basser at the Institute of Medical Research of the Royal North Shore Hospital, Sydney (unpublished work), who found some evidence for a greater uptake of iron-59 in hæm *a* of liver than in that of heart. The work of Gallagher, Judah and Rees[3], who studied the effect of copper deficiency in rats, also indicated that hæm *a* was rapidly synthesized in the liver.

Rawlinson and Hale's method[4] for separation of hæmin *a* and protohæmin was improved and incorporated in a method of isolation which gives hæmin *a* usually containing less than 10 per cent of admixed protohæmin in a yield of 80–90 per cent of that present in the first extract from the tissues; protohæmin free from hæmin *a* is obtained in approximately 50 per cent yield.

The freshly excised organs were squeezed thoroughly in heparinized saline so as to remove as much blood as possible, and washed with saline. Homogenates prepared in homogenizers of the Potter–Elvehjem type were washed twice with 0·2 *M* sodium acetate buffer of *p*H 5·2 to remove hæmoglobin and myoglobin. The residue was treated with a solution containing 2 ml. of *n*-butanol per 30 ml. of water for 10 min. at 45° C. and finally washed twice with 80 per cent aqueous acetone (v/v).

The hæmins were extracted by 80 per cent acetone containing 0·7 per cent (w/v) of hydrochloric acid, using 50 ml. for the hearts, 100 ml. for the kidneys, and 300 ml. for the livers of 10 rats. The hæmins were brought into ether with dilute hydrochloric acid and the ether solutions washed three times with the dilute acid, adding some ferrous sulphate during the second washing. The hæmins were then separated by distribution between pyridine – ether and aqueous hydrochloric acid – pyridine according to Rawlinson and Hale's method, except that the ether phase was repeatedly washed with large amounts of the aqueous phase until the absorption band of protohæmochrome had disappeared, leaving hæmin *a* of 90–95 per cent purity. The hæmins of the first two aqueous extracts, almost pure protohæmin, were brought back into ether with 10 per cent hydrochloric acid.

Blood was collected by heart puncture, and an ether solution of its protohæmin prepared from it. Ferritin was isolated in rather low yield from a portion of the liver homogenate as described by Theorell *et al.*[1] and its iron determined by Trinder's method[5].

The hæmins were extracted from their ether solutions with 0·1 *N* sodium hydroxide and measured spectrophotometrically as hæmochromes in 20 per cent pyridine – 0·1 *N* sodium hydroxide – sodium dithionite, applying the formula of Lemberg *et al.*[6]. Hæmin iron was calculated by assuming a molecular weight of 652 for protohæmin and 870 for hæmin *a*.

Radioactivity was counted in an annular well scintillation counter and corrected, for decay, to the day of injection. The total isolation procedure could be carried out in three days.

Ten rats weighing about 150 gm. each were used for each experiment. Each rat received intraperitoneally about 2 μc. labelled ferric ammonium citrate containing 5–10 μgm. of iron and giving a count of 102,000 per min.

Table 1

	Counts/min. per 10 rats with standard deviations* after		Specific activities (counts/min./μgm. iron) after :	
	7 days	14 days	7 days	14 days
Blood†	337,000 ± 2,100	389,000 ± 1,000		
Protohæmin				
Heart	50 ± 3·5	62 ± 4	8·7	6·9
Kidney	280 ± 12	131 ± 10	8·4	8·4
Liver	1,180 ± 46	2,050 ± 46	8·2	8·2
Blood	—	—	8·8	8·1
Hæmin *a*‡				
Heart	24 ± 2·5	26 ± 3	4·5	3·9
Kidney	104 ± 6	92 ± 4	9·6	9·8
Liver	212 ± 10	280 ± 20	12·9	12·5
Liver/ ferritin§	33,600 ± 600	12,700 ± 370	12·9	6·0

* Standard deviations apply only to the counting procedure.

† Assuming the blood volume of the rat to be 10·0 ml.

‡ Specific activities corrected for protohæmin content which was as follows : after 7 days, heart 6, kidney 7, liver 10 per cent ; after 14 days, heart 0, kidney 1, liver 27 per cent.

§ Isolation incomplete.

As expected, most of the radioactive iron is found in the ferritin and hæmoglobin. The specific activities, however, of the hæmins isolated from the organs are similar to those of hæmoglobin–protohæmin. There are no significant differences of blood protohæmin and the protohæmin from the organs, with the possible exception of the heart. A substantial and variable part of the protohæmin isolated from the organs is, however, derived from hæmoglobin and myoglobin, which our procedure failed to remove completely, and not from cytochromes of type *b*.

The specific activity of hæmin *a* proves that iron is rapidly incorporated into the cytochromes of type *a*. A comparison of the specific activities of protohæmin and hæmin *a* shows that the incorporation into hæm *a* exceeds that into protohæm in the kidney and especially in the liver, whereas in the heart the hæm *a* activity is distinctly smaller. These findings agree with the observations of Gallagher, Judah and Rees[3] that cytochrome oxidase and hæmin *a* rapidly decrease in copper deficiency and are rapidly restored by copper, and that the decrease is more marked in the liver than in the kidney. Their experiments differ, however, from ours in that a physiologically abnormal deficiency of hæm *a* was present which may have provided an extra stimulus for hæm *a* synthesis.

The differences between the one- and two-week experiments are scarcely significant, except that the total activity in hæmoglobin has risen, and the specific activity in liver ferritin has decreased, as expected. Experiments will be carried out with shorter times of incubation to obtain more information on the rates of incorporation of iron. It will also be of interest to see whether hæm *a* is synthesized *in vitro* by liver homogenates, as Minakami, Yoneyama and Yoshikawa[7] have recently reported for cytochrome *b*.

We are indebted to Prof. C. Rimington for allowing this work to be carried out in his Department, and for his help in the animal experiments, to Miss E. M. Clarkson for the estimation of the iron content of the ferritin preparations, and to the Australian National Health and Medical Research Council for a travel grant.

R. Lemberg
A. Benson

Department of Chemical Pathology,
University College Hospital Medical School,
London, W.C.1.
Dec. 12.

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Rate of Exchange of Phosphate in Red Blood Cells : Effect of Thyroid Hormones

A METHOD for the *in vivo* determination of the rate of exchange of phosphate in red blood cells by means of the s^{32}P coefficient has already been described. This coefficient measures the outflow of phosphorus-32 from circulating labelled red blood cells[1]. It has been shown that s^{32}P represents the turnover-rate of acid-soluble phosphate in the red blood cell[2].

The exchange-rate of phosphorus-32 has been studied by means of this technique in man and rat under different conditions of thyroid activity.

In euthyroid men, the mean value of s^{32}P for 170 determinations is $4 \cdot 4 \pm 0 \cdot 3 \times 10^{-4}$/min. Hyperthyroidism (32 cases) and hypothyroidism (23 cases) are characterized by s^{32}P coefficients of $5 \cdot 3 \pm 0 \cdot 4$ and $3 \cdot 3 \pm 0 \cdot 4 \times 10^{-4}$/min. respectively.

In the rat, the mean value of 7·0 ± 0·5 × 10^{-4}/min. in 20 controls reaches 7·9 ± 0·4 (17 animals) after treatment with thyroid extract for 30 days and decreases to 5·7 ± 0·5 (20 animals) after continuous administration of methyl-mercapto-imidazol for the same period of time. In these various conditions there was no significant modification of the soluble phosphate concentration of the red blood cells. It was possible to establish a high correlation between the variations of the s^{32}P coefficient and the basal oxygen consumption measurements.

These findings imply a close relationship between thyroid activity and the turnover-rate of acid-soluble phosphate in the red blood cells. From preliminary *in vitro* experiments, it seems that the thyroid hormone acts directly on phosphate transfer: *in vitro* addition of *l*-triiodothyronine (5 μgm. per cent) to labelled red blood cells, incubated in non-radioactive plasma of myxœdematous patients, is followed by an increase of the outflow-rate of phosphorus-32.

A. M. Ermans
P. A. Bastenie

Medical Clinic and Isotopes Laboratory,
St. Peter Hospital,
University of Brussels. Dec. 18.

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Enzymatic N-Methylation of Histamine

The *in vivo* studies of Schayer[1] have shown ring N-methylation to be the principal pathway of histamine metabolism in a variety of mammalian species. His work demonstrates the following scheme:

histamine ⟶ 1-methyl-(β-aminoethyl) imidazole
(methylhistamine)
⟶ 1-methylimidazole-4-acetic acid

Kobayashi[2] found that incubation of histamine with whole-liver homogenates resulted in the formation of 1-methylimidazole-4-acetic acid. These observations reflect the summation of at least three enzymatic processes, one of which is concerned with the synthesis of a co-factor needed for histamine methylation. This report describes the isolation and properties of an enzyme, imidazole N-methyl transferase, which catalyses the ring-N-methylation of histamine requiring S-adenosylmethionine as the methyl donor.

The enzyme was purified approximately eight-fold in two steps from the soluble supernatant fraction of mouse liver. After homogenization of mouse liver with 4 vol. of isotonic sucrose and centrifugation at 78,000*g*, the supernatant fraction was adjusted to *p*H 5·0 with dilute acetic acid and heated for 5 min. at 50° C. After centrifugation, the precipitate was discarded and the supernatant fluid fractionated with ammonium sulphate. The protein fraction precipitated between 50 and 70 per cent saturation was centrifuged, dissolved in 0·01 *M* phosphate buffer *p*H 7·4 and dialysed against 0·001 *M* phosphate buffer *p*H 7·4 overnight. The partly purified enzyme can be stored frozen for several weeks at – 10° C. without loss of activity.

Enzymatically formed methylhistamine was extracted with chloroform at alkaline *p*H[3]. Under these conditions, 88 per cent of the methylhistamine, but only 7 per cent of the histamine, are extracted into the chloroform.

Table 1 shows the absolute requirement by the purified enzyme for S-adenosylmethionine. Magnesium ions and reduced glutathione are not necessary in this system. Furthermore, dialysis of the enzyme against versene or the addition of versene to the reaction mixture does not alter the enzymatic activity. This indicates that imidazole-N-methyl transferase differs from catechol-O-methyl transferase[4]. Enzymatic activity is not altered by pretreatment of animals with 'Marsilid', a monoamine oxidase inhibitor which blocks the conversion of methylhistamine to 1-methylimidazole-4-acetic acid[3].

Table 1. Requirements for Ring-N-Methylation of Histamine by Purified Mouse Liver Enzyme

Reaction mixture*	Methylhistamine formed (μmoles)
Whole system	0·041
Whole system + 2 mgm. reduced glutathione	0·043
Omit magnesium chloride	0·044
Omit S-adenosylmethionine	0·000
Preheated enzyme	0·000

* Reaction mixture containing 2 ml. 0·1 *M* phosphate buffer *p*H 7·4, 0·5 ml. purified mouse-liver enzyme (0·22 mgm. protein), 0·4 μmoles S-adenosylmethionine, 20 μmoles magnesium chloride, 0·05 μmoles histamine dihydrochloride labelled with carbon-14 (Nuclear Chicago) (12,500 c.p.m.), in a final volume of 3·0 ml. was incubated at 37° C. for 4 hr.

The reaction mixture was saturated with sodium sulphate after the addition of 0·5 ml. of 5 *N* sodium hydroxide and the methylhistamine extracted with 15 ml. chloroform. An aliquot of chloroform was evaporated to dryness, the residue eluted with 0·5 ml. of hyamine (ref. 8) and phosphor and counted in a 'Tri Carb' liquid scintillation counter.

The enzymatic product was proved to be methylhistamine by three techniques. After cochromatography in ethanol/0·1 *N* hydrochloric acid (95 : 5) of the enzymatic product and synthetic methylhistamine[3], a radioautograph demonstrated a single spot which exactly coincided in R_F and shape with the ninhydrin-stained area. The specific activity remained constant after four recrystallizations as the dipicrate[5] with added carrier. Finally, incubation with mouse liver homogenate formed radioactive 1-methylimidazole-4-acetic acid. This was proved as follows: Enzymatically formed methylhistamine was incubated with whole mouse liver homogenate for 4 hr. The mixture was boiled, filtered and passed through a 'Dowex-1'-acetate 100–200 mesh column (10 cm. × 1 cm.). The column was washed and then eluted with 0·5 *N* acetic acid. After concentration of the eluate, it was recrystallized from acetone/water with carrier 1-methylimidazole-4-acetic acid (synthesized from cyanomethylimidazole[6] by Pyman's method[7]). There was no decrease in specific activity after four recrystallizations while carrier imidazole acetic acid could readily be freed of radioactivity by this technique.

Imidazole-N-methyl transferase has been found to be present in most tissues of all species studied so far, and appears to be of paramount importance in histamine metabolism. A more detailed study of this enzyme will be the subject of a future communication.

Donald D. Brown
Julius Axelrod
Robert Tomchick

Laboratory of Clinical Science,
National Institute of Mental Health,
Bethesda, Maryland. Dec. 18.

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Inactivation of Isoniazid by Peroxidase

INVESTIGATIONS on enzymes of *Mycobacteria* reported from this laboratory[1] and elsewhere[2,3] have shown the importance of cellular peroxidase for the activity of isoniazid. Results of an extension of these studies bearing on the effect of peroxidase on the tuberculostatic activity of isoniazid form the basis of the present communication.

Using *Mycobacterium tuberculosis H37Rv* as the test organism, growth studies were carried out on Youman's medium (without serum) and the observations were made usually at the end of three weeks incubation at 37° C. Horse-radish peroxidase (obtained through the courtesy of Dr. E. F. Hartree, Molteno Institute of Biology and Parasitology, Cambridge), beef-liver catalase (Boehringer) and mammalian cytochrome *c* (Boehringer) were sterilized by Seitz filtration, whereas hæmin (Roche), hæmoglobin (Difco) and isoniazid (Roche) were autoclaved; 0·05 c.c. of the test organism, grown for 10 days on Dubos 'Tween' albumin medium, was used as the inoculum per tube.

Table 1. EFFECT OF PEROXIDASE AND RELATED COMPOUNDS ON GROWTH-INHIBITION OF *Mycobacterium tuberculosis H37Rv* BY ISONIAZID

Supplement	Conc. γ/c.c.	Isoniazid (γ/c.c.)							
		0	0·05	0·1	0·5	1	5	10	25
None (control)		+	+	−	−	−	−	−	−
Peroxidase	3	+	+	+	+	+	+	+	+
	1·5	+	+	+	+	+	+	+	−
	0·6	+	+	+	+	+	+	−	−
	0·3	+	+	+	+	+	+	−	−
	0·15	+	+	+	+	+	−	−	−
	0·03	+	+	+	+	+	−	−	−
	0·015	+	+	+	+	−	−	−	−
Peroxidase (inactivated)	3	+	+	−	−	−	−	−	−
Hæmin	10	+	+	+	+	+	+	+	+
	5	+	+	+	+	+	+	−	−
	2·5	+	+	+	+	+	−	−	−
	1	+	+	+	+	−	−	−	−
	0·5	+	+	−	−	−	−	−	−
Catalase	10	+	+	−	−	−	−	−	−
Hæmoglobin	10	+	+	−	−	−	−	−	−
Cytochrome *c*	10	+	+	−	−	−	−	−	−

+, growth; −, no growth.

The mean results of several experiments are summarized in Table 1. Fisher[4] first demonstrated, later confirmed by Knox[5], that hæmin strongly antagonized isoniazid. It was further shown that it breaks up isoniazid to di*iso*-nicotinoyl-hydrazine and *iso*-nicotinic acid[6,7]. In the present study, it is seen that while on a weight basis peroxidase is 100 times as active as free hæmin, on the basis of its hæmin content, which is 2·5 per cent, it is 4,000 times more active. The fact that inactivated (autoclaved) peroxidase showed no effect indicates that the reaction is enzymatic and specific, since the other hæm-proteins were without activity.

These experiments were carried out with extracellular peroxidase. Isoniazid-susceptible tubercle bacilli have, however, the peroxidase at the surface and intracellular. Thus, isoniazid could be fixed to the bacteria and broken down within the cell. If the breakdown products are liberated outside by extracellular peroxidase, they may not enter the bacterial cell.

Much work has been done on the possible modes of the action of isoniazid. Investigations of our own demonstrated that isoniazid does not act by inhibition of either catalase or peroxidase[8], and we proposed a mechanism by which isoniazid is fixed to susceptible cells and metabolized with a peroxidase–oxidase system[9] similar to that of tryptophan proposed by Knox and Mehler[10].

That the activity of isoniazid may be due to its breakdown to peroxide is not supported by the fact that the more peroxide-susceptible, catalase-negative mutants are, on the contrary, resistant to the drug. Further, the action of peroxidase is also not merely due to its removal of peroxide, since otherwise catalase should have been equally effective.

These studies emphasize that the breakdown products of isoniazid, other than peroxide, eventually exert the inhibitory effect by blocking an essential function once they are transported across the cell membrane into the cell.

M. O. TIRUNARAYANAN*
W. A. VISCHER*

Medical Section,
Schweiz. Forschungsinstitut für Tuberkulose,
Davos.

Dec. 22.

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* Present address: c/o J. R. Geigy S.A., Basle, Switzerland.

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Quantitative Estimation of Purines by the Visual Scanning of Photographs of Paper Chromatograms

ESTIMATION of microquantities of purines by paper chromatography was first suggested by Hotchkiss[1]. Later, detection by photographing with an ultraviolet source has amplified the method[2]. Tennent *et al.*[3] and others have designed adaptors for the Beckman spectrophotometer to enable direct estimation of the purines from paper chromatograms. This method requires costly instrumentation, and is time-consuming unless an automatic recorder is provided. Other authors have estimated the size of the spot[4] produced on the photograph.

To obtain a quantitative relationship between area and concentration it is necessary that a spot of accurate dimensions be placed on the starting line. This is frequently difficult. We have been able to produce quantitative results by the scanning of photographs on an automatically recording (visual) densitometer designed by us and reported in detail in a subsequent paper. The densitometer has a high sensitivity, which enables density as well as area definition to be recorded.

Fig. 1, showing typical calibration curves of adenine and adenosine, was obtained by the following method. The standards 0·02, 0·04 and 0·08 μmole of the substance were spotted on to Whatman No. 1 paper. The three concentrations were developed on the same paper with *iso*-propyl ether, 90 per cent (w/v) formic acid, (3 : 2)[5] for 6 hr. by the ascending technique. The papers were then dried and photographed by contact photography on to 'Kodagraph' contact paper (extra thin) using a B.G.E. germicidal lamp to produce the image[6]. The print was slightly overexposed to ensure an even black background.

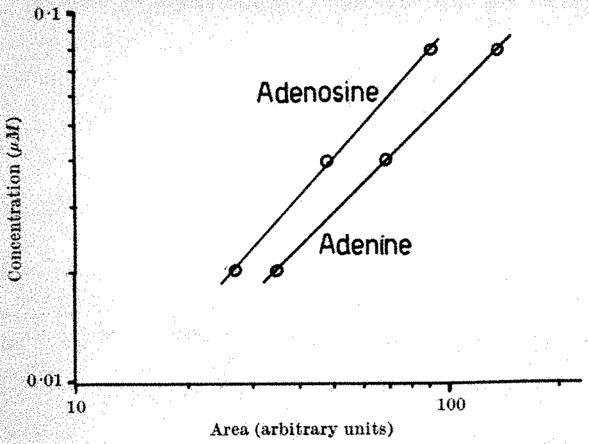

Fig. 1

The print was then developed, fixed and dried in the usual way. The print was cut in 2-in. strips and scanned. The record produced gave a tracing of the absorption of the spot. The area under the curve was estimated with an 'Allbrite' planimeter, and this area was plotted on a double logarithmic graph against the concentration of the purine. The resulting plot gave a linear calibration. It was found that the base-line obtained on such a curve was more stable than that obtained by scanning a blank filter paper. The method is also applicable to other substances, such as steroids[7], which have absorption properties in the ultra-violet regions.

We wish to acknowledge financial assistance from the National Health and Medical Research Council of Australia and General Motors Holden.

B. M. JOHNSTONE*
G. P. BRINER

Department of Pharmacology,
University of Melbourne,
Carlton, N.3.

* General Motors Holden Fellow.

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Detection of Gentiobiose and Sophorose in Cultures of Certain Micro-organisms growing in Defined Glucose-containing Media

THE ability of cellulose-forming species of *Acetobacter* to produce from glucose a mixture of melibiose, cellobiose, cellotriose, cellotetraose and fructose, together with higher oligosaccharides some of which yield fructose on hydrolysis, has been reported in recent communications[1-3]. We have now examined the behaviour, in comparable conditions, of *Acetobacter aceti* N.C.I.B. 8554, *Acetobacter rancens* N.C.I.B. 7214, *Acetobacter acidum-mucosum* N.C.I.B. 8133, and *Acetobacter acetosum* var. *nairobiense* N.C.I.B. 7212, none of which produces cellulose. *A. aceti* was grown in a medium containing (gm./l.): $(NH_4)_2SO_4$, 3; $MgSO_4.7H_2O$, 2; KH_2PO_4, 3; glucose, 30. The same ingredients with addition (gm./l.) of: DL-alanine, 0·1; asparagine, 0·1; calcium D-pantothenate, 0·002; riboflavin, 0·002 and biotin, 0·0003, were employed to make up the medium for the three other species. These media were dispensed in volumes of 200 ml. in sixteen Glaxo flasks, four flasks for each species. After inoculation and incubation for 10 days at 28° C. the contents of each set of four flasks were Seitz-filtered and concentrated to about 50 ml. in presence of a little barium carbonate *in vacuo* at 35°. Each concentrate was filtered and treated in the following manner in all four cases. It was added to a column (4·5 cm. diameter) filled with a charcoal–'Celite' (50 : 50, w/w) mixture. The column was eluted with water (5 l.) and then with aqueous ethanol solutions containing, respectively, 5, 15, 20 and 35 per cent (v/v) of ethanol. The aqueous ethanolic eluates were combined (4 l.), concentrated under low pressure at 35° C. to 500 ml. and treated successively with 'Zeo-Karb 225' (H^+ form) and 'De-Acidite *E*' (OH^- form).

After removal of these resins the solution was concentrated further to a syrup and examined in three ways by paper chromatography using: (*a*) *n*-propanol–water–ethyl acetate, 7 : 2 : 1 by vol.; (*b*) pyridine–water–ethyl acetate, 1 : 2 : 2 by vol.; and (*c*) the method of Bayly and Bourne[4], in which comparison is made of the benzylamine derivatives of sugars.

The chromatographic pattern afforded by the products of each species of *Acetobacter* was the same in all cases. Two disaccharides and one higher oligosaccharide predominated in each culture, and these disaccharides showed the mobilities of gentiobiose and sophorose, respectively, when run against authentic disaccharides by procedures *a*, *b* and *c*.

A. rancens was now employed in an experiment with 30 l. of medium. After incubation the metabolism solution was concentrated in presence of barium carbonate *in vacuo* at 35° C., filtered and subjected to charcoal–'Celite' treatment. The aqueous ethanolic eluates were combined, concentrated *in vacuo* at 35° C., desalted in the manner described by Walker and Wright[2] and oligosaccharides left in solution were separated by gradient elution from charcoal, following the technique of Bacon and Bell[5]. 95 fractions, each of 200 ml., were collected. From fractions 15–60 two reducing sugars were isolated, purified by band paper chromatography and examined in the solvents of *a*, *b* and *c*, in which they were indistinguishable from gentiobiose and sophorose, respectively. Also, on hydrolysis each yielded solely glucose, and on acetylation each yielded an acetate which on combustion gave values corresponding to $C_{28}H_{38}O_{19}$, the empirical formula for a disaccharide octa-acetate. Final confirmation of identity was obtained in each case by paper ionophoresis in borate buffer *p*H 10 at 800 V. for 3 hr.

In a study of glucose metabolism in *Aspergillus nidulans* Eidam, the mould was grown as surface cultures on a solution which contained (gm./l.): NH_4NO_3, 3·00; K_2SO_4, 0·22; $NaH_2PO_4.2H_2O$, 7·30; $MgSO_4.7H_2O$, 5·00; $FeCl_3.6H_2O$, 0·16; $ZnSO_4.7H_2O$, 0·05 and glucose, 100.

After 8 days at 26° the metabolism solution (20 l.) was filtered and concentrated in presence of a little barium carbonate at 35° to a thin syrup. This was subjected to charcoal–'Celite' chromatography to eliminate hexoses, as described by Bacon[6]. After removal of ethanol-insoluble salts of phosphoric acid esters[2] the oligosaccharide fraction was desalted with 'Zeo-Karb 225' and 'De-Acidite *E*', concentrated at

35°, and subjected to gradient elution with water and with aqueous ethanol from a charcoal–'Celite' column[7]. 96 fractions, each of 100 ml., were collected and contained three disaccharides and three higher oligosaccharides. Fractions 27–40, which contained principally disaccharides, were combined, evaporated to low bulk and resolved by cellulose column chromatography into three fractions containing two main components and a third component in traces. By band paper chromatography these two main components were isolated in pure condition. Each yielded only glucose on hydrolysis and each gave an acetate, $C_{28}H_{38}O_{19}$. By chromatographic procedures similar to those used for the products of the *Acetobacter* species and by ionophoresis in borate buffer *p*H 10 at 900 V. for 3 hr., the two disaccharides were shown to be gentiobiose and sophorose.

These results are of interest in relation to questions concerning cellulose synthesis by *A. acetigenum* and the formation of β-linked glucosaccharides by moulds. It is intended to report the work in more detail elsewhere.

For gifts of specimens of rare sugars we are indebted to Dr. J. S. D. Bacon, Prof. K. Freudenberg, Dr. L. Hough, Prof. S. Peat, Dr. Elizabeth Percival and Dr. W. J. Whelan, and we are grateful to Dr. S. A. Barker, who carried out for us an ionophoretic identification.

A. W. KHAN
D. N. PELLEGRINO
T. K. WALKER

College of Science and Technology,
University of Manchester. Dec. 31.

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Malonate Metabolism by Plant Tissues

INTEREST in malonic acid has been largely directed towards its role as a competitive inhibitor of succinic dehydrogenase. Very little attention has been directed towards the occurrence of malonic acid in plant tissues or toward the metabolism of malonic acid *per se*. In 1952 Bentley[1] showed malonate to be present in about eighteen species of leguminous plants. Malonic acid has also been reported in species from families other than the legume family[1-3]. That malonic acid could be metabolized was established more than thirty years ago when it was shown that malonate could serve as the sole carbon source for certain bacteria[4]. More recent work established that malonate was readily metabolized by enzyme preparations from fungi[5,6], mammals[7,8], and plants[9,10]. The present communication reports a wide range of higher plants which possess the ability to metabolize malonate.

The procedure involved submerging the petiole of excised leaves into a vial containing 60 μmoles 2-^{14}C labelled malonate (specific activity = 1,000 c.p.m./μmole). The leaves were permitted to absorb the labelled malonate for 17 hr., at which time the leaves were oven-dried and the organic acids extracted with hot water. The organic acids were then separated by paper chromatography (ether/acetic acid/water, 4 : 1 : 5) and the individual organic acids counted on a gas-flow counter. The radioactivity in the individual organic acids (except malonate) was summed and the percentage of the total activity contributed by each acid calculated (Table 1). When radioactivity within an individual acid failed to exceed twice background, the percentage of the total count for that acid was listed as 'trace'.

Table 1. PERCENTAGE CONTRIBUTION BY INDIVIDUAL ACIDS TOWARD TOTAL RADIOACTIVITY IN ORGANIC ACID FRACTION OF LEAVES FOLLOWING 17-HR. ABSORPTION PERIOD OF 2-^{14}C MALONATE THROUGH LEAF PETIOLE

Plant species	Malic	Citric	Succinic	Fumaric	Unidentified acids*
Lantana	30	17	9	6	38
Fig	26	10	7	*T*	54
Peach	24	9	11	*T*	55
Apple	39	8	*T*	*T*	50
Sweet orange	35	21	*T*	*T*	38
Eucalyptus	34	9	*T*	*T*	52
Coffee	13	14	*T*	*T*	64
Strawberry	45	15	*T*	*T*	34
Azalea	21	5	*T*	*T*	71
Walnut	26	*T*	14	*T*	45
Camellia	14	*T*	13	*T*	59
Soybean	35	*T*	24	*T*	30
Boysenberry	33	*T*	*T*	*T*	45
Corn	27	*T*	*T*	*T*	40
Tomato	46	*T*	*T*	*T*	40

* Unidentified acids, usually three or four in number, were situated near the origin and in most cases were poorly resolved.
T, Trace (radioactivity failed to exceed twice background).

Table 1 lists the percentage radioactivity present in individual organic acids following a 17-hr. absorption period of 2-^{14}C malonate through the leaf petiole. The presence of radioactivity in organic acids indicated that malonate was metabolized and that the No. 2 carbon was incorporated into various acids. Comparing the radioactivity among the isolated acids, it may be noted that malate in each case contained the largest percentage of radioactivity, followed in most cases by citrate, succinate, and fumarate, respectively. Substantial quantities of radioactivity were also present in several unidentified acidic constituents possessing quite low R_F values. Identification of these acidic constituents is incomplete.

The fifteen plant species which are listed in Table 1 were selected at random from forty-five species examined. The thirty unlisted species follow: acacia, almond, blackeye pea, bougainvillea, bush bean, cactus, cherimoya, eugenia, feijoa, fuschia, geranium, hydrangea, ivy, loquat, morello cherry, mustard, natal plum, papaya, passion fruit, pear, persimmon, poinsettia, potato, rose, rough lemon, sunflower, trifoliate orange, tropical guava, white sapote, and wing nut. Substantial radioactivity was detected in one or more of the Krebs cycle acids in each species examined.

Working with particulate enzyme preparations, Young and Shannon[10] recently suggested that the pathway of malonate metabolism in bush bean leaves proceeded according to the following scheme:

$$\text{malonate} \longrightarrow \text{malonyl coenzyme } A \longrightarrow \text{acetyl coenzyme } A$$

The product of this reaction scheme, acetyl coenzyme *A*, was then available for condensation with oxalacetate and subsequent oxidation by the Krebs cycle. While only respiratory reactions were investigated, it was suggested that the product, acetyl coenzyme *A*, participated in other reactions as well. Brady[11] reported recently that malonyl coenzyme *A* was an active participant in fatty acid synthesis.

The radioactive assay results indicated that forty-five species, comprising twenty-seven families, incorporated the No. 2 carbon of malonate into one or more of the identified acids—malate, citrate, succinate, or fumarate. In view of the large number and diversity of species performing this incorporation, it is suggested that the enzyme(s) capable of metabolizing malonate may be widespread throughout the plant kingdom.

LELAND M. SHANNON
ROGER H. YOUNG
CARLTON DUDLEY
Department of Horticultural Science,
University of California,
Los Angeles 24. Dec. 23.

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Micro-volume Drop-plate Assay of Antibiotics

IN assaying antibiotic substances by any of the well-known plate diffusion methods it is necessary to dilute the unknown solution to varying degrees, depending on the original concentration. In addition to minimizing the possible disturbing influence of interfering substances and the *p*H of the original sample in the assay plate, this procedure has the practical convenience of providing inhibitory zones of a suitable size-range needed for a satisfactory assay. However, if one could run good assays on the original concentrated samples without resorting to serial dilution it would simplify the assay procedures. We have found that such a step is possible with the use of a micrometer syringe which would enable one to spot micro-volumes directly on the assay plate with great accuracy. These minute volumes dry rapidly and form discrete spots, giving uniformly circular inhibition zones after allowing proper diffusion and incubation periods.

In order to test the practicability of the outlined approach, several four-point assays were run on liquid samples containing penicillin by both the conventional cup-method and the micro-volume drop-plate method, the latter with the aid of a micrometer syringe ('Agla' brand, Burroughs Wellcome and Co.). In both cases the plates were prepared according to the enriched seed layer method described by the U.S. Food and Drug Administration[1], using 'Difco Penassay' base and seed agars. The assay organism was *Bacillus subtilis* A.T.C.C.6633. In the droplet method, in place of cups, the same volumes of a suitable penicillin *G* standard and the unknown—usually, 0·4 and 1·6 μl., corresponding to two and eight small divisions on the peripheral scale of the micrometer head—were spotted directly on the agar surface. Assay values were calculated from the resulting inhibition zones using Miyamura's nomogram[2].

Results of the assays given in Table 1 show that the droplet method as used by us is quite satisfactory, and the errors involved cannot be considered to be higher than in the commonly used cup, cylinder and bead-modifications of the plate assays. In our experience, the method is simpler than these other conventional plate methods and less time-consuming, as highly concentrated unknowns can be used directly in the assay plate. The method has no material disadvantages except, perhaps, the increased concentration and care required of the operator while adding small volumes represented by one or two small divisions on the peripheral scale of the micrometer head. However, with the addition of a semi-automatic addition mechanism such as the one described earlier[3], this method is capable of being developed into a good routine tool for assaying not only antibiotics but also other compounds which are physiologically active in agar plate methods involving micro-organisms or cell-lines.

Table 1. PENICILLIN TITRES OF UNKNOWNS IN UNITS/ML.

Sample No.	Cup-plate assay	Micro-volume drop-plate assay
1	1,020	1,010
2	2,020	2,000
3	2,180	2,390
4	1,860	1,840
5	1,910	2,050
6	1,740	1,700
7	2,180	1,940
8	1,598	1,557
9	1,650	1,683

Further evaluation of the method is being published in detail elsewhere.

I am indebted to Dr. A. H. Amin, director of research, for the encouragement he has given me in this work. I also wish to acknowledge the technical assistance of colleagues in the microbiological research laboratory.

M. R. S. IYENGAR
Microbiological Research Laboratory,
Alembic Chemical Works Co.,
Baroda. Jan. 12.

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Incidence of the Erythrocytic Defect associated with Drug-Sensitivity among Oriental Subjects

IN the past few years a new type of metabolic lesion of the red cell has been elucidated. It was found that sensitivity to the hæmolytic action of the 8-aminoquinoline primaquine and many other compounds was due to an intrinsic defect of the red cell[1]. This defect can be demonstrated *in vitro* by: (1) incubating the red cells with a solution of acetylphenylhydrazine and observing the pattern of Heinz body formation[2], and (2) incubating the red cells with acetylphenylhydrazine or a number of other substances and measuring the level of reduced glutathione after an incubation period of 2 hr. (the glutathione stability test)[3], or (3) measuring the activity of the enzyme glucose-6-phosphate dehydrogenase in the red cells[4].

It has been known for some time that sensitivity to drug-induced hæmolysis varies considerably in different racial groups. Application of these *in vitro* techniques has disclosed marked differences in the incidence of this red-cell defect in various population groups. Thus, the defect is common in American Negroes, but rare in most Caucasian populations. It is relatively common in Sardinia, and in Israel has been found to occur commonly in Sefardic, but not in Aschkenazy Jews. As might be expected, the incidence of drug-induced hæmolytic anæmia and favism (which occurs only in individuals with this red-cell defect) is highest in those groups that have a high incidence of the red-cell defect as demonstrated by *in vitro* means. Available data regarding incidence and distribution of this defect, as elucidated by many authors, have been reviewed recently[5].

Several cases of fava bean-[6], 8-aminoquinoline-[5], and naphthalene-induced hæmolytic anæmias[7] in oriental people have been reported in the literature, but the incidence of this red-cell defect in this race has not been determined. For this reason, we have applied the glutathione stability test to 99 subjects of oriental origin, mostly students, all residing in the United States. The test was carried out exactly as described originally by one of us, except that 1 ml. of acid–citrate–dextrose solution was used as anticoagulant per 5 ml. of whole blood. This permits cold storage of blood samples for as long as 3 or 4 weeks before the test is performed[8]. In the studies described here, the test was always performed within 10 days of the time the blood was drawn. In the case of the single positive reactor detected, the test was repeated with a freshly drawn sample of blood, both with heparin and acid–citrate–dextrose solution used as anticoagulant. The test for sensitivity using Heinz bodies was carried out as described previously[2]. The assays for glucose-6-phosphate dehydrogenase and 6-phosphogluconate were carried out by means of a slight modification of the method described by Marks[9].

The results of studies on the stability of glutathione are given in Table 1. The red cells of all subjects tested contained more than 37 mgm. per cent reduced glutathione after incubation with acetylphenylhydrazine except for the one positive Thai subject. His red cells contained 15 mgm. per cent reduced glutathione after incubation with acetylphenylhydrazine. In the case of the positive reactor, an assay for glucose-6-phosphate dehydrogenase showed that only 4·0 units/gm. of hæmoglobin were present, as compared with a mean normal of 15·9 units/gm. of hæmoglobin as reported by Marks[9]. 6-Phosphogluconic dehydrogenase activity was normal. The Heinz body pattern, after incubation with acetylphenylhydrazine, was typical of drug-sensitive red cells.

Table 1. PLACE OF ORIGIN OF ANCESTORS OF 99 ORIENTAL SUBJECTS TESTED

Place of origin	Sex	Number tested	Positive test
Total Chinese	M	41	0
	F	36	
By Province:			
Chekiang	M	2	0
	F	5	
Fukien	M	5	0
	F	4	
Hopei	M	0	0
	F	2	
Hunan	M	1	0
	F	0	
Kiangshu	M	4	0
	F	1	
Kwantung	M	18	0
	F	23	
Shantung	M	1	0
	F	0	
Szechuan	M	1	0
	F	0	
Unclassified	M	9	0
	F	1	
Burma	M	1	0
	F	1	
Thailand	M	8	1
	F	1	0
Japanese	M	6	0
	F	2	
Korean	M	2	0
	F	0	

The observations presented here are too limited in scope to allow us to draw any quantitative conclusions about the incidence of this defect in oriental populations. It would seem, however, that while this defect does exist among oriental people, the incidence among at least one group, the Chinese, is low.

The co-operation of Drs. S. Larsh and V. Minnich in obtaining blood samples from Thai subjects and of Dr. W. T. Wong in obtaining samples from Chinese subjects, is greatly appreciated.

ERNEST BEUTLER
MARY K. Y. YEH
THOMAS NECHELES

Argonne Cancer Research Hospital*,
and the Department of Medicine,
University of Chicago,
Chicago, 37. Dec. 17.

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* Operated by the University of Chicago.

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Taurine in Human Blood Platelets

Morita and Asada[1] have shown a considerable amount of taurine and other sulphur compounds to be present in the platelets of human blood. We have attempted to determine the level of taurine in platelets and the probable metabolic pathway of its formation.

The suspension of platelets was obtained from the blood of healthy humans. The blood was mixed with 5 per cent solution of ethylenediamine tetraacetic sodium salt (10 : 1), and centrifuged many times. The suspension usually contained 2,000,000–3,000,000 platelets/c.mm. counted by the Rees–Ecker method. The contamination by erythrocytes and leucocytes did not exceed 0·1 per cent. The platelets obtained in this manner showed metabolic activity for more than 10 hr. when their oxygen consumption was investigated in Cartesian divers. In the course of investigation the platelets were suspended in physiological solution with an addition of phosphate buffer *p*H 7·3. For quantitative estimation of taurine, 0·3 ml. of the platelet suspension was cytolysed by quick freezing and thawing followed by incubation with a drop of toluene[2] for 20 min. The cytolysate was passed through a column of 'Zeo-karb 225' in the acid form. In these conditions the resin retains the salts and amino-acids, and the taurine and cysteic acid pass through quantitatively into the filtrate[3]. The filtrate was evaporated to dryness and dissolved in 0·2 ml. of redistilled water. A 15-μl. sample was applied eccentrically on a Whatman No. 1 paper disk, and circular chromatography was run for 15 hr. in water–butanol–acetic acid solvent (5 : 4 : 1). The spots were detected by staining with ninhydrin[4]. The quantitative estimation was performed by extinction measurements of the eluate from paper using a Coleman or Hilger spectrophotometer. The error of this method was found to be ± 3·3 per cent.

For investigation of the formation of taurine in the platelets, the suspensions were incubated with $0{\cdot}02\ M$ solutions of cysteine or cysteic acid for 15 hr. in air or nitrogen atmosphere. After incubation the samples were cytolysed and the taurine was estimated as described above. In each experiment the level of taurine was compared with the content of this compound in the platelets from the same specimen of blood without incubation (blank).

We have examined platelets from the blood of 21 normal persons. We have found that the amount of taurine per platelet varies in different persons between $6{\cdot}2 \times 10^{-8}$ μgm. and $9{\cdot}8 \times 10^{-8}$ μgm.; in most cases it was more than $8{\cdot}0 \times 10^{-8}$ μgm. Recalculated per unit of wet weight, this gives a value of 1·5 mgm. of taurine per gm. of platelets.

In the platelets incubated with cysteic acid we have sometimes found a small increase in the amount of taurine. The amount of cysteic acid in the suspension fluid always decreases during the experiment. After incubation of the platelets with cysteine, an increase of about 20–40 per cent in the taurine content was shown in all experiments. If parallel incubations were carried out of two samples at the same time, one with cysteic acid and the other with cysteine, we always found a greater increase in the amount of taurine in the sample with cysteine. An example of a typical experiment is given in Table 1.

Table 1

Suspension of platelets	Preparation of sample	Results (μgm.)	
		Taurine	Cysteic acid
Blood group O 2,600,000 platelets/c.mm. 1,100 erythrocytes/c.mm. 700 leucocytes/c.mm.	Blank platelets cytolysed and denatured + cysteic acid and cysteine	4·3	68
	Sample I platelets incubated 15 hr. in air with cysteine	6·3	trace
	Sample II platelets incubated 15 hr. in air with cysteic acid	5·0	60

We confirmed the production of taurine in the platelets by using cysteine labelled with sulphur-35. The spot of taurine from platelets was radioactive when the suspension was incubated with labelled cysteine.

These results show that in the blood platelets of normal persons the taurine-level is constant. Taurine is produced in the platelets, and cysteine is a better substrate for its formation than cysteic acid. This fact suggests that the taurine in human platelets is formed from cysteine through cysteine sulphinic acid and hypotaurine. Therefore, the mechanism of taurine formation in human platelets resembles that described by Bergeret *et al.*[5] and Awapara[6] in rats.

Further investigations are in progress.

JULIAN FRENDO
ALEKSANDER KOJ
JAN M. ZGLICZYŃSKI

Department of Physiological Chemistry,
Medical Academy,
Cracow. Dec. 4.

Detection of Antigens as Specific Precipitates on Paper Electrophoresis Strips

AGAR diffusion[1] has been used for detecting antigens after paper electrophoresis. I have found that a precipitin reaction can be carried out directly on the paper.

After electrophoresis, a strip of paper dried at room temperature is placed in contact with filter paper previously moistened with sufficient antiserum to saturate the applied paper. The papers are left in a closed container for 2–4 hr. The electrophoresis strip is then removed and immersed in 0·9 per cent (w/v) sodium chloride for several minutes if Whatman No. 1 paper is used, or overnight for Whatman No. 3 *MM* paper. Nine further washings of 1 min. each are sufficient to remove excess antiserum. The washed strip is dried and stained with bromphenol blue[2]. Specific precipitates appear as dark blue spots on a light blue background.

The method has been applied to the demonstration of a serum protein antigen after electrophoresis in a veronal–borate buffer and of a polysaccharide from *Mycoplasma mycoides*[3] (Fig. 1). The polysaccharide has been detected after electrophoresis in $0{\cdot}05\ M$ acetate, veronal and borate buffers over the range of *p*H 4–11.

The following points should be noted: (1) Large amounts of antigen may yield spots with white centres due to local antigen excess. (2) Intensity of spot colour may not be proportional to the amount of antigen present. Partially overlapping spots may not be distinguishable. (3) Irreversibly adsorbed protein, present before application of serum, may cause artefacts.

While this work was proceeding, a method of detecting antigens on paper by simultaneous electrophoresis of antigen and serum[4] was published.

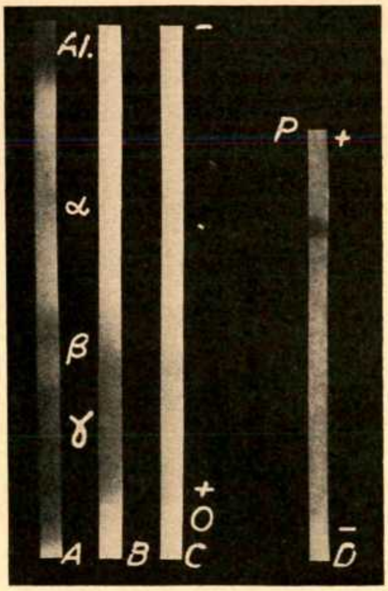

Fig. 1. *A*, *B*, *C*, bovine serum 0·01 ml./5 cm. width paper, applied at origin *O*. Electrophoresis in veronal borate *p*H 8·6. *A*, untreated, stained; *B*, treated with anti-γ-globulin serum, washed and stained; *C*, treated with control serum, washed and stained. *A*1, α, β, γ represent albumin, α-, β- and γ-globulins respectively. *D*, 10 μgm. *M. mycoides* polysaccharide applied at *P*. Electrophoresis in $0{\cdot}05\ M$ borate *p*H 11. Treated with immune serum, washed and stained

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I wish to thank Dr. A. W. Rodwell and Mr. P. Plackett for their advice and support.

S. Buttery

Animal Health Research Laboratory,
Division of Animal Health and Production,
Commonwealth Scientific and
Industrial Research Organization,
Parkville, N.2,
Victoria, Australia. Dec. 23.

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Changes in *p*H and Temperature in Poultry Breast Muscles at Slaughter

During a study of factors which might affect the tenderness of poultry meats, some observations were made on the changes in *p*H and temperature occurring in the breast muscle of birds during and after slaughter.

Needle electrodes (Beckman No. 40470) and a thermocouple were tied into the muscle prior to slaughter. The thermocouple was connected to a recorder and the temperature was automatically recorded at ½-min. intervals. *p*H readings were made every 30 sec. during the first 5 min. or so and then at 2- or 5-min. intervals, depending on the rate of fall of the *p*H.

The birds were slaughtered in a manner simulating commercial practice, that is, they were suspended head down and the throat cut. This procedure leads to a rapid bleeding.

Chickens, turkeys and geese were examined.

In all the types of birds examined there was a rise in temperature within 5 min. of the throat being cut, followed by a slow fall. In chickens and turkeys this was most marked, as is shown in Fig. 1, in some cases being as much as 3·5° F. The rise in geese was not as marked and in no case exceeded 1° F. This rise is probably due to continued work by the muscle in the absence of the heat-regulating power of the blood. Chicken and turkey breast muscles are 'white' meats, whereas goose breast muscle is a 'dark' meat. It would appear that there is a definite difference in the temperature reaction of these two types of muscles.

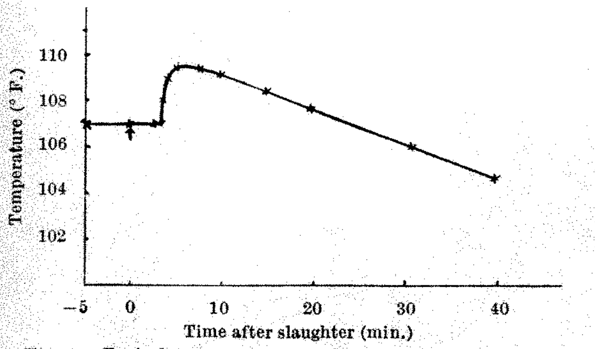

Fig. 1. Typical temperature response of turkey breast muscle after slaughter

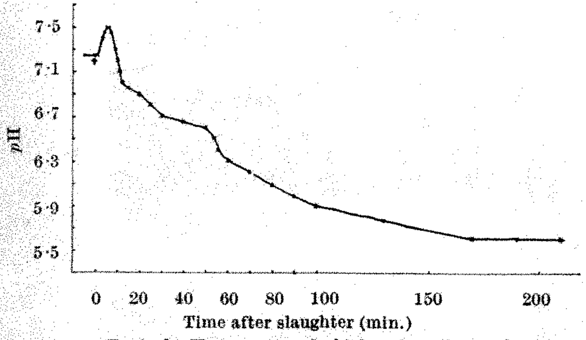

Fig. 2. Typical *p*H response of chicken breast muscle after slaughter

Also, in all the types of poultry examined there was at first a rise in *p*H followed by a gradual stepwise decline as is shown in Fig. 2.

Table 1 gives the mean and range *p*H and temperature rises.

Table 1

Type of bird	No. of birds	Mean *p*H rise	Mean temperature rise (° F.)
Chicken	15	0·20 (0·05–0·30)	1·0 (0·0–2·0)
Turkey	5	0·25 (0·05–0·50)	2·1 (1·00–3·50)
Goose	6	0·15 (0·05–0·25)	0·55 (0·25–0·75)

(Figures in brackets are the range)

Reports by Bate-Smith and Bendall[1] and Scaife[2] on the changes in *p*H occurring in beef and pork muscle after slaughter make no mention of the rise in *p*H that was observed in these studies. This may be due to the initial *p*H being defined (Bate-Smith[1]) as "the *p*H of the muscle within 5 minutes of slaughter". In most cases it was found that the *p*H had already begun to decline 5 min. after slaughter.

A full report of this work will be published elsewhere.

F. E. Peters

Department of Biochemistry,

J. W. Dodge

Department of Poultry Science,
Purdue University,
Lafayette, Indiana. Dec. 23.

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Relaxation of Glycerol-treated Muscle Fibres by Acetone

Certain sulphydryl reagents such as 'Salyrgan'[1] and certain chelating agents such as ethylenediamine tetraacetate[2,3] have been known to have a lengthening action on glycerinated muscle fibres in the presence of adenosine triphosphate. A reasonable explanation of this relaxing action by 'Salyrgan' has already been given[1]. The chelating actions of ethylenediamine tetraacetate and its analogues are of interest. We have reported[4], however, using seven different chelating agents, that their chelating activities were not parallel with their relaxing capacities. Thus the mechanism of these agents remains unsolved.

It was found that acetone had a reversible relaxing action on glycerinated fibres, like ethylenediamine tetraacetate and 'Salyrgan' (Fig. 1). The concentration of acetone required was rather high, but the action was not due to the non-specific effect of high concentration of non-electrolyte, because sucrose and glycerol were quite ineffective in much higher concentration. Acetylacetone and ethyl acetate, especially the latter, were much more effective than acetone, but they were not so complete as acetone in their

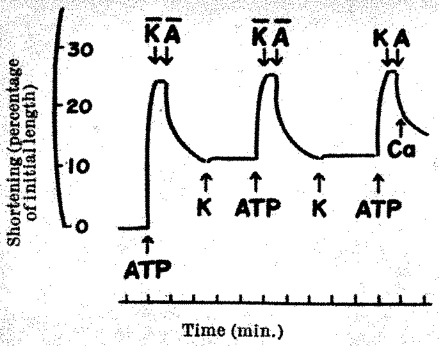

Fig. 1. Extension effect of acetone in the presence of adenosine triphosphate. K, 0·15 M potassium chloride solution containing 0·01 M magnesium chloride and 0·02 M *tris*-(hydroxymethyl)-aminomethane-maleate buffer (pH 6·8); $\overline{K}$, K without magnesium chloride. ATP, 5 mM adenosine triphosphate in K. A, 10 per cent acetone by volume and 5 mM adenosine triphosphate in K. $\overline{A}$, 10 per cent acetone by volume and 5 mM adenosine triphosphate in $\overline{K}$. Ca, calcium chloride added; final concentration, 8 mM

reversibility. Dioxane was also prominent in producing extension, but the fibres lost their contractility completely.

Acetone by itself had little plasticizing action and did not have a significant effect on the adenosine triphosphatase activity of muscle fibres or actomyosin. In the presence of inorganic pyrophosphate or tripolyphosphate, however, acetone exerted a strong relaxing action on fibres without affecting their contractility (Fig. 2). In other words, acetone accelerated remarkably the plasticizing action of pyrophosphate or tripolyphosphate. This suggests that acetone lengthens muscle fibres by enhancing the plasticizing action of adenosine triphosphate.

The effects seem almost the same for ethylenediamine tetraacetate and its analogues as for acetone (Fig. 2). It would be premature, however, to conclude that these facts also explain the mechanism of ethylenediamine tetraacetate relaxation, because the contractility of fibres treated by both ethylenediamine tetraacetate and pyrophosphate was scarcely restored, that is, the relaxation was not reversible. Further studies are needed in this case.

In contrast to these reagents, 'Salyrgan' and p-chloromercuribenzoate showed only a little, if any, accelerating action on the action of pyrophosphate. Granules in skeletal muscle[5,6], which are now accepted as the essential relaxing factor, also did not enhance the plasticizing action of pyrophosphate.

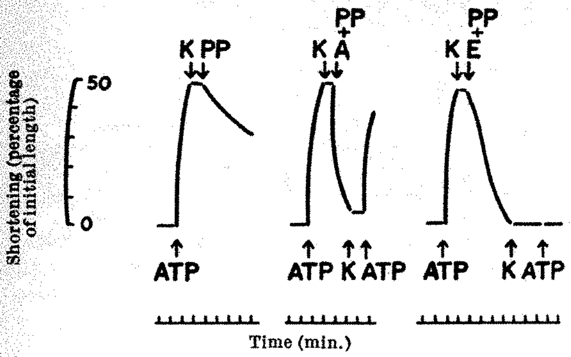

Fig. 2. Acceleration of pyrophosphate action by acetone and ethylenediamine tetraacetate. PP, 1 mM pyrophosphate in K (Fig. 1); $PP+A$, 1 mM pyrophosphate and 10 per cent acetone by volume in K; $PP + E$, 1 mM pyrophosphate and 1 mM ethylenediamine tetraacetate in K; K and ATP, similar to Fig. 1 but at pH 6·6

These observations suggest that there are different kinds of mechanisms for relaxation of glycerol-treated muscle fibres. Further details will be published elsewhere.

We wish to thank Prof. H. Kumagai for his encouragement, and also Dr. S. Watanabe for discussions.

SETSURO EBASHI
FUMIKO EBASHI

Department of Pharmacology,
Faculty of Medicine,
University of Tokyo,
Bunkyo-ku, Tokyo. Dec. 6.

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Effect of the Rate of Elimination of Digoxigenin in the Guinea Pig on the Determination of its Lethal Dose

WHEN a drug is given by intravenous infusion it is not possible to define its lethal dose if it is detoxified rapidly, because the apparent lethal dose will depend on the rate of administration of the drug. This difficulty has been emphasized by Beccari[1], who pointed out that in the case of drugs which are rapidly eliminated it is better to define a 'lethal rate' of infusion rather than a lethal dose. The problem of deciding at which rate of infusion to determine the lethal dose has always been apparent in the study of cardiac glycosides, and has been accentuated by the earlier need for biological assay of these drugs. The relationship between rate of infusion and lethal dose of cardiac glycosides and aglycones is complex, depending both on the individual drugs and the species used for the determination of toxicity. In the British Pharmacopœia (1958) and the U.S. Pharmacopœia (thirteenth revision) this problem is defined by laying down maximum and minimum times during which each determination of lethal dose must be made. From Table 1 it can be seen that the apparent lethal dose of digoxigenin determined in the guinea pig depends on the time taken to produce death. At the lower rates of infusion in which the time to produce death is prolonged, the apparent lethal dose has the highest values.

Earlier methods designed to measure the rate of elimination of cardiac glycosides[2,3] did not permit any investigation of the effect of dose on the rate of elimination of these drugs, although it would be expected that the rate of elimination would increase with increasing concentrations of the drug in the

Table 1. LETHAL DOSES OF DIGOXIGENIN IN THE GUINEA PIG

Apparent lethal dose (mgm./kgm.)	Time of infusion (min.)	Rate of infusion (mgm./kgm./min.)	True lethal dose (mgm./kgm.)
9·97	48·6	0·205	5·12
7·78	28·8	0·270	5·13
7·67	26·0	0·295	5·27
5·51	18·0	0·306	4·22
5·28	18·0	0·293	4·10
4·58	16·6	0·276	3·58
Mean 6·80			4·57
Variance 4·10			0·485

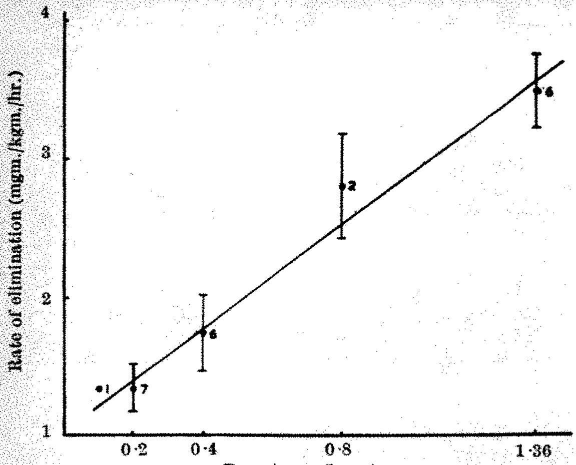

Fig. 1. The relationship between the dose of digoxigenin and its rate of elimination in the guinea pig. The figures beside the points indicate the number of observations at each dose, and the standard errors of these observations are represented by the vertical lines

animal's tissues. By using the method of determining the duration of action of cardiac glycosides described previously[4] it has been possible to establish the relationship between the dose of digoxigenin given and its rate of elimination in the guinea pig. In this method, injections of a suitable dose of adenosine are given regularly at 2-min. intervals. The responses of heart block are recorded on an electrocardiogram, and the duration of each response is measured. After an intravenous injection of digoxigenin the responses to adenosine are at first more prolonged and then gradually this potentiation decreases. The duration of action of digoxigenin is taken as the time during which the responses to adenosine remain potentiated. Fig. 1 shows the effect of increasing dose-levels of digoxigenin upon its rate of elimination by the guinea pig. This graph is based on 22 observations from 12 guinea pigs. The line drawn on the graph is the calculated regression line giving the best fit to the data. Measurements have been made with doses of digoxigenin up to 20 per cent of the dose which kills the guinea pig when infused during 15–30 min., and it is not feasible to administer larger doses in a single injection. The mean rate of elimination of digoxigenin was 1·87 mgm./kgm./hr. per mgm./kgm. For the purpose of the following calculation, it has been assumed that this relationship holds with higher doses of digoxigenin. This figure can then be used in conjunction with experimental results of rates of infusion of digoxigenin and the times to death to calculate the amount of drug actually present in the animal at the time of death, that is, the 'true' lethal dose.

Let D = dose-level actually present in the animal (amount given less the amount eliminated, mgm./kgm.); x = rate of infusion (mgm./kgm./min.); y = rate of elimination (mgm./kgm./min. per mgm./kgm.); = time after start of infusion (min.).

Then:

$$\frac{\mathrm{d}\,(D)}{\mathrm{d}t} = x - yD$$

$$\int \frac{\mathrm{d}\,(D)}{x - yD} = \int \mathrm{d}t$$

$$-\frac{1}{y}\log(x - yD) = t + C \qquad (1)$$

When $t = 0$, $D = 0$, and $C = -\frac{1}{y}\log x$

Substituting in (1) and rearranging:

$$D = \frac{x - \exp(-yt + \log x)}{y}$$

From this formula the 'true' lethal dose of digoxigenin (D) has been calculated for each of the six guinea pigs which received continuous infusions of digoxigenin until death, using the data shown in Table 1. It can be seen that the mean dose of digoxigenin infused into the guinea pig to produce death is about 1½ times the mean amount actually present in the guinea pig at the moment of death. If the scatters of the observations of the apparent lethal dose and of the true lethal dose about their respective means are examined it can be seen that the variance is considerably less when correction has been made for the amount of digoxigenin which has been eliminated during the course of the determination of lethal dose, and this reduction is statistically significant ($F = 8{\cdot}22$, $P < 0{\cdot}05$).

M. RAND*
ANNE STAFFORD†

Department of Pharmacology,
University of Sydney.

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* Present address: Department of Pharmacology, Oxford.

† Present address: Nuffield Institute for Medical Research, Oxford.

[1] Beccari, E., *Arch. intern. Pharmacodyn.*, **73**, 65 (1946).
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Triiodothyronine in Acute Alcoholic Intoxication

REPORTS in the lay press of the sobering effect of triiodothyronine in intoxicated humans suggested to us the desirability of investigating the effect of this compound on acute alcoholic intoxication under controlled conditions in the laboratory. To this end varying doses of triiodothyronine (3,3′,5-triiodo-L-thyronine as either the free acid or the sodium salt, obtained from Sigma Chemical Co.) were administered intraperitoneally to normal female dogs of 10–15 kgm., after which a dose of 3·0 gm. per kgm. of ethyl alcohol, diluted to 15 per cent with normal saline, was administered intravenously over a period of about 30 min. At the end of 1 hr. after the start of the injection, and afterwards each hour for 7 hr., samples of venous blood were drawn for alcohol analyses[1] and the degree of intoxication assessed according to an arbitrary scale of 10 stages used for many years in this laboratory[2]. Controls were run on each animal, varying only in the absence of the injection of triiodothyronine.

The initial concentration of alcohol in the blood less the concentration at the end of the experiment, divided by the time-interval, gave the rate of disappearance of alcohol from the blood-stream, expressed in mgm. per 100 ml. per hr., which is a reliable index of the rate of alcohol metabolism. The degree of intoxication plotted against the concentration of blood alcohol yielded a curve that made it possible by interpolation to estimate the degree of intoxication at each decrement of 20 mgm. per 100 ml. This device enabled us to average the degree of intoxication at a given blood alcohol-level for a group of dogs.

Two groups of dogs were used, with some of the animals common to the two groups. All had been

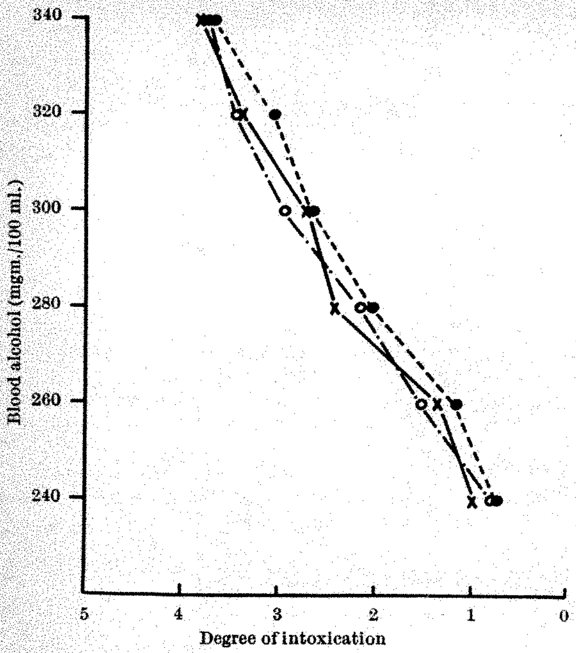

Fig. 1. Degree of intoxication at a given blood alcohol concentration in the same group of 4 dogs with and without pre-medication with triiodothyronine. ×—×, Control; ○—·—○, triiodothyronine 250 μgm; ●--●, triiodothyronine 375 μgm.

in the laboratory more than three months, and had received numerous similar alcohol injections at intervals of not less than one week. Group 1 consisted of 4 dogs. Their average rate of fall in concentration of blood alcohol on control runs was 20·9 mgm. per 100 ml. blood per hr. When 250 μgm. triiodothyronine were administered to the same dogs 30 min. before the alcohol injection the rate was 19·3, while with 375 μgm. triiodothyronine it was 19·1, an insignificant difference. Fig. 1 shows that with the smaller dose the degree of intoxication at a given concentration of alcohol in the blood was almost identical with the control, while the larger dose evoked a small but probably not significant improvement in performance.

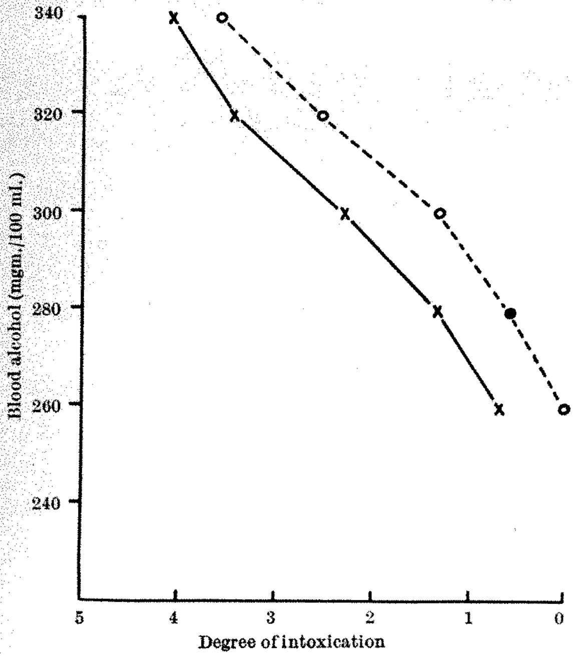

Fig. 2. Degree of intoxication at a given blood alcohol concentration in the same group of 6 dogs with and without pre-treatment with triiodothyronine 2·5 or 5·0 mgm. at 20 hr., and again 30 min. before administration of alcohol. ×—×, Control; ○--○, triiodothyronine

Group 2 consisted of 6 dogs. Their control rate of fall of blood alcohol was 20·9 mgm. per 100 ml. Four of these dogs received 2·5 mgm. triiodothyronine at 20 hr. and again at ½ hr. before the alcohol injection. The remaining two received 5·0 mgm. at each of these times. The only symptoms shown by the dogs after these very large doses of triiodothyronine were some panting and a transient rise in temperature of not more than 1 deg. C. The rate of fall of blood alcohol after triiodothyronine was 21·3 mgm. per 100 ml., an insignificant increase over their control value. Fig. 2 shows that with these very large doses of triiodothyronine the degree of intoxication was about 1 degree less at all blood alcohol concentrations, or, in other words, the same degree of intoxication occurred at a blood alcohol concentration about 20 mgm. per 100 ml. higher than in the control runs.

The small but significant reduction in the degree of intoxication brought about by triiodothyronine would indicate, if applied to man, that about one more drink could be consumed before reaching a given degree of drunkenness. If the dog and man show a comparable response to triiodothyronine, the effective dose for man would be in the vicinity of 12·5–25 mgm., which is much in excess of any reported dose. The possibility of species difference would indicate the desirability of repeating the work with human subjects, using maximal safe doses of triiodothyronine.

Henry Newman
Marion Edmonds Smith
Division of Neurology,
Department of Medicine,
Stanford University School of Medicine,
San Francisco. Dec. 11.

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Adrenal Cortical Function in the Pregnant Sheep

Relatively little is known regarding the role of the adrenal cortex in human pregnancy. Conflicting reports appear in the literature on steroid excretion-rates in women during normal pregnancy. Some workers[1] have found no change in 17-ketogenic steroid excretion in the last trimester of pregnancy, while others[2], using the same chemical method for their estimation, report a slight increase in levels. In contrast, Venning[3], employing a bioassay technique as a measure of adrenal activity, found an initial rise in excretion of glycogenic corticoids in the first trimester of human pregnancy. This later returned to normal values with a falling-off in excretion-rate usually occurring in the last month. Shortly after parturition the values were back to normal levels again.

It was therefore decided to initiate a preliminary study on the ewe to see if any noticeable change in urinary corticoid excretion occurred in this animal during pregnancy and post-partum. This was part of a more extensive study on a possible relationship between adrenal function and birth-weight of the lamb.

Four ewes were observed over the period from conception to lambing and during a few weeks following parturition. Two of the ewes received intramuscular injections of adenocorticotrophic hormone during the last 3 months of pregnancy (dosages of 20 and 40 I.U./day respectively), while the remaining two were untreated.

The chemical method of Norymberski and Stubbs[1] was used for determining urinary excretion of steroids. This method estimates 17-ketogenic steroids. Included in this steroid group is tetrahydrocortisone, a metabolite of hydrocortisone, the main cortical steroid secreted into the blood-stream of sheep[4]. The finding that a marked rise in urinary steroid excretion (rise $>$ 200 per cent) was observed after administration of adenocorticotrophic hormone and a rapid fall occurred when injections of the hormone ceased (fall to 20 per cent) provided physiological justification for the method.

Results showed that, during the greater part of pregnancy, urinary steroid excretion in the sheep did not differ significantly from the seasonal fluctuation of high winter and low summer levels observed in the controls. This seasonal steroid pattern had also been observed previously in man[5]. However, of interest was the marked drop in steroid output which occurred towards the end of pregnancy in all animals studied, treated and untreated with adenocorticotrophic hormone. The urinary output remained still very low immediately following the birth of the lamb, rose during the lactation period and showed a drop when lactation was terminated experimentally. These fluctuations are illustrated in Fig. 1, which is typical of the responses shown by all the animals observed.

A more detailed investigation is being undertaken which will give day-by-day information of steroid excretion-rates over the last month of pregnancy. This should show if the drop in output occurs suddenly or shows a stepwise fall over several days or weeks.

The noticeable fall in steroid excretion just prior to parturition may have one of several explanations:

(1) Reduced adrenal cortical activity; (2) altered enzyme activity in the adrenal gland, such as the possible metabolism of progesterone to the steroids concerned with salt and water transfer—corticosterone and aldosterone—rather than its hydroxylation to hydrocortisone; (3) a possible drop in level of circulating progesterone of extra-adrenal origin affecting the amount of adrenal steroid production; (4) reduced stimulus for a possible extra adrenal source of corticosteroids.

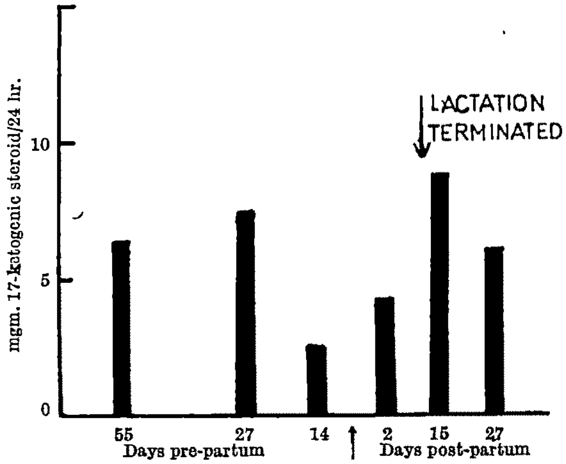

Fig. 1. Urinary 17-ketogenic steroid output in a pregnant ewe before and after parturition. A marked drop in corticoid excretion occurred towards the end of pregnancy, preceding parturition

Further work is required to be done before an adequate explanation can be formulated.

This study was financed by the National Health and Medical Research Council of Australia.

The assistance of Mr. L. Morris in the management of the animals is gratefully acknowledged.

KATHLEEN W. ROBINSON

Sir William Macgregor School of Physiology,
University of Queensland,
Brisbane.

Dec. 19.

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Effect of Dietary Phytate on Fæcal Absorption of Radioactive Ferric Chloride

IT has been stated that diets with high phosphate, phytate and low calcium content affect iron absorption by precipitating the iron as an insoluble iron phytate or phosphate; and that this might be a factor in the etiology of the widespread and severe iron-deficient anæmias of the tropics[1-6]. It is known that bulk has a deleterious effect on iron absorption.

Most tropical diets are rich in phosphate and phytates, have a low calcium content and consist largely of bulky carbohydrates. Such diets might be expected to hinder iron absorption.

The approximate milli-equivalents in an 'average' tropical diet of calcium is 20, phosphate 32, phytate 12, iron 0·7 (20 mgm. Fe^{2+}). If combination of iron with phytates and phosphates occurs in the gut it might be expected that on such a diet little iron would remain free; supplementary iron might leave excess of the metal free for absorption. Although the role of calcium in iron absorption is somewhat controversial, calcium in excess might be expected to form calcium phytates and phosphates, and thus reduce the quantity of these compounds available for combination with iron[7-12].

It is likely that all these compounds are mutually reacting and the changes in one will affect the others, and no one of them can be regarded as exclusively concerned in hindering iron absorption or otherwise.

To ascertain the effect of dietary phytates on intestinal iron absorption we have used 6·0–10·0 μc. of oral $^{59}FeCl_3$ with 5 mgm. of carrier in a form of ferrous sulphate with ascorbic acid, and estimated the radioactivity of the stools daily. Absorption of iron was determined by measuring the differences between the activity of the radioiron given and the unabsorbed activity recovered from the fæces; utilization was measured by determining the amount of radioactivity that appeared in the circulating blood as newly synthesized hæmoglobin; this has been found to be the most accurate for determining the iron absorption[13].

The radioactivity of the wet stools was estimated using a ring of six 10-in. matched halogen-quenched Geiger–Müller tubes. The stools were then dried and powdered and the activity re-measured in the Geiger–Müller counter as well as in a scintillation counter using a 1½-in. thallium-activated sodium iodide crystal.

The subjects, non-anæmic healthy African adults, were given 50 gm. wholemeal bread spread with jam to which was added 3 gm. of 12-sodium phytate; 10–15 ml. water containing the $^{59}FeCl_3$ were then drunk and after this a further 50 gm. of wholemeal bread given. In this way dietary bulk was kept constant. All the stools thereafter were collected daily and analysed separately until they contained less than 1 per cent of the administered radioactivity. One week after this level had been reached, a second similar dose of $^{59}FeCl_3$ was given, but this time with identical amounts of white bread and no phytate. Duplicate tests were then made on the same individuals, reversing the order in which the phytate-fortified diet was given.

Our results indicate that the effect of excess 12-sodium phytate on intestinal iron absorption is varied. In some cases phytate may decrease iron absorption by 20 per cent. For example, an individual given 6 μc. of oral $^{59}FeCl_3$ with 5 mgm. of carrier but no phytate excreted 57 per cent of the administered dose of iron. A second test made on the same individual with the same amount of iron and a similar diet but the latter fortified with 3 gm. of 12-sodium phytate gave an excretion rate of 74 per cent, and a fourth test made without phytate gave an excretion value of 82 per cent (Table 1).

Table 1. PERCENTAGE OF IRON EXCRETED

Case No.	No phytate	3 gm. phytate	No phytate
1	57	74	82
2	88	70	68
3	60	58	76
4	72	85	62
5	80	70	85

These iron excretion-rates are lower than those found in normal European and American subjects, and approximate to the excretion values found in anæmic patients in America and Britain. Perhaps this is because the iron stores, as estimated by the iron content of bone marrow, are lower than in Europeans and Americans.

Under the conditions of this experiment and using 12-sodium phytate, there were great variations in the amount of iron absorbed and the effect of phytate on its absorption was not constant.

In man, intestinal iron absorption is not constant, the same individual absorbing different amounts at different times and different individuals have varying absorption-rates. Anæmic individuals generally absorb more iron than non-anæmic, and this is not directly associated with the hæmoglobin values or the extent of their iron stores. Our work, however, was all done on the same non-anæmic individuals, and the different excretion-rates cannot therefore be due to either anæmia, or variations in the extent of their iron stores.

It is unlikely that differences in iron absorption on phytate-fortified diets are due to variations in the hydrolysis of phytic acid to inositol and orthophosphoric acid in the gut. Part of the phosphate thus liberated would be available for either absorption or combination with other metals. The extent to which dodeca-sodium phytate undergoes hydrolysis in the gut of man has not yet been worked out but is probably high. It is possible that phytates *per se* have no adverse effect on iron absorption but that the products of its hydrolysis may, in so far as they increase the milli-equivalents of phosphates present in the gut which could combine with available iron and/or calcium. Many animals, particularly the rat, have phytase-producing bacteria in their gut which decompose the phytates before they precipitate iron or calcium; whether this happens in man is unknown. Since dietary bulk was kept constant in all our tests, this is not likely to have entered into the variations in iron absorption.

Whatever part calcium, phosphates and phytates are ultimately found to play in iron absorption and the etiology of tropical iron-deficient anæmias, the work of Hernden and his associates[14] with D-sorbitol makes it evident that the composition of the diet and the intestinal contents play an important part in iron absorption.

Full results of this work will be published elsewhere.

HENRY FOY
ATHENA KONDI
W. H. AUSTIN

Wellcome Trust Research Laboratories,
P.O. Box 30141, Nairobi,
Kenya.
Dec. 24.

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BIOLOGY

Radiosensitivity as a Function of Antigenic Equivocation

RECENT studies of factors modifying the response of mammalian tissues to radiation have led to results which cannot be interpreted on existing theories, and a more comprehensive hypothesis on the nature of radiation reactions in multicellular organisms seems necessary. Previous studies on the *C3H* mouse mammary carcinoma had shown that its radiosensitivity apparently depends on an auto-immunizing mechanism or similar manifestation of host resistance, and is consequently determined largely by the degree of genetic and antigenic diversification between host and tumour. This interpretation, however, is not sufficient to explain more recent results on the induced radiosensitization of unmodified isogenic tumours by inoculation of the host with a second, suitably attenuated, inoculum. For example, irradiated isogenic tissues, including tumour isografts given a dose sufficient to prevent their 'taking', will, when inoculated into a mouse already bearing a growing tumour graft, render the established tumour materially more radiosensitive[1].

Since isologous transplants are, by nature, not antigenic in the classical sense, it was concluded that the irradiated inoculum must contain a new or modified antigen capable of influencing a pre-existing balance between the growing tumour and

Table 1. Effect of Various 'Antigens' on the Radiosensitivity of the *C3H* Isologous Tumour treated *in situ* with 4,200 r.

Sensitizing inoculum	No. of mice	Number cured	Cures (per cent)
Uninoculated controls	108	0	0
Irradiated *C3H* tissues, < 5,000 r.	92	26	28
7,000 r.	72	28	39*
10,000 r.	44	8	18
Isografts (unirradiated *C3H* skin)	22	0	0
Hybrid grafts (F_1 and back-cross skin)	44	7	16
Homografts (albino mouse tissues)	74	24	32*
Heterospecific grafts (rat skin)	22	4	18
Heterogeneric proteins (unrelated tissues)	24	0	0

* Note the similarity between homografts and optimally irradiated isografts in their radiosensitizing capacity.

resistance factors in the host. This conclusion has since been confirmed by the demonstration of antigenic changes appearing in irradiated tumours[2] and host tissues[3].

If the radiation-attenuated sensitizing inoculum acts through the formation of a new antigenic constituent, then one would expect that unirradiated homologous tissues from other strains or closely related species, having antigens resembling, but not identical with, those of the tumour, should also have a potent radiosensitizing action. Experiments designed to test this prediction gave positive results (Table 1). Living skin from homologous and related hybrid donors, as well as other homologous tissues and even heterologous skin from a related genus, did in fact succeed in sensitizing the tumour. As in the case of radiation-attenuated isografts, optimal sensitization was obtained when the antigenic constituents of the inocula resembled, but were neither identical with nor too divergent from, the antigens of the tumour and host.

These complex interactions can, it would seem, best be analysed in terms of biological information theory[4]. The effect of irradiation on intracellular structure and function has been ascribed to tautomeric re-arrangement of molecular configuration in the nucleic acids[5], equivalent to the superposition of 'noise' or 'equivocation' upon a specific signal. This would be expected in turn to alter the specific pattern of newly synthesized tissue antigens, including those concerned with homeostatic control of proliferation and growth. Thus radiation-induced equivocation could also affect intercellular regulatory processes.

When a tissue is irradiated *in situ* the degree of equivocation, in effect the noise/signal ratio, apparently becomes sufficient for the autogenous cells to lose their specific identity, and hence become subject to immune processes such as the homograft reaction. The similarities between radiation effects and the phenomena of transplantation immunity have been discussed elsewhere[1]. The inoculation of radiation-attenuated isografts or of genetically incompatible homografts into tumour-bearing animals, both amount to the injection of distorted information into the intercellular feedback system, thus disturbing the existing relatively tolerant host–tumour relationship. This should amplify the effects of local irradiation, and hence account for the induced radiosensitization of tumours.

Since 'information', in the sense used above, is carried by specific material entities, it can be postulated that the 'equivocated substances' generated by irradiation of tissues must be mobile, reaching distant lymphoid tissues in order to evoke the immunological reactions described; diffusible, affecting areas adjacent to the treated site and determining the radiation reaction at these points; and unstable, the local concentration tending to diminish during the post-irradiation period, resulting in a dependence on time in the dose–response relationship. While the first accounts for the experimental results described, the two latter postulates promise to throw some light on the mechanisms underlying the time and volume parameters affecting dosage in clinical radiotherapy.

The 'diffusion' effect has been observed in irradiated human tissue by the increased radiosensitivity of skin adjacent to another treated area, and by the dependence of the intensity of the reaction upon the size and shape of the treated field[6]. Similarly, loss of activated material by decay or reversion to the ground-state amounts to partial 'recovery' from the effects of radiation. The material is likely to be a heterogeneous mixture, and if each product is assumed to decay exponentially the total residual activity, given by the sum of the exponentials, should approximate to a 'power function'[7]. This is in line with the clinical observation that the dose (D) which, when delivered over an extended period (T), is equivalent in effect to a single instantaneous exposure (E), is given to a very close approximation by the power function $D = E \times T^n$, n being a positive fraction[8].

The foregoing 'equivocation' hypothesis could serve to systematize a complex body of data in the field of experimental mammalian radiation biology, and might also furnish a satisfactory explanation for the time and volume factors as they affect the radiosensitivity of human tissues and tumours.

L. Cohen
A. Cohen

Radiobiological Laboratory,
Radiation Therapy Department,
Johannesburg Hospital.
Dec. 29.

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Demonstration of Endogenous Pyrogen in Serum during Systemic Tuberculin Reaction in Rabbits

Substances capable of producing fever in normal recipients (the so-called endogenous pyrogens) appear in the serum of experimental animals during fever due to bacterial endotoxin, influenza virus and streptococcal and pneumococcal infections[1]. Systemic tuberculin reaction is very similar to the effect of bacterial endotoxins[2]. An attempt has therefore been made to demonstrate the presence of substances with an effect corresponding to that of endogenous pyrogen in the serum of experimental rabbits during systemic tuberculin reaction.

Induction of hypersensitivity in rabbits with B.C.G. infection, signs of systemic tuberculin reaction and passive transfer of hypersensitivity with white blood cells and spleen cells have been described elsewhere[3]. Blood was collected under sterile conditions by cardiac puncture approximately 2 hr. after intravenous administration of purified tuberculin (0·005 mgm. PPD). It was allowed to clot, kept overnight in an ice-box, the serum was drawn off, centrifuged at 2,000 r.p.m. for half an hour and kept at − 20° C. All glass used, syringes and needles were washed thoroughly in water free of pyrogen before sterilization and all sera were tested for sterility. Rabbits were rendered tolerant to endotoxin by 10 daily injections of 10^8 heat-treated *Salmonella paratyphi B*. Tolerance was tested daily by taking body-temperatures after injection of *S. paratyphi*; the sera were tested on the first day after the last injection of the vaccine. Sera were injected intravenously in doses of 10–25 ml. Body-temperatures were recorded with a rectal thermometer twice within the $\frac{1}{2}$ hr. preceding the experiment and then $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 3 and 4 hr. after injecting the serum. Rabbits having a temperature higher than 39·5° C. or showing a difference of more than 0·2 deg. C. between the measurements before the experiment were not used.

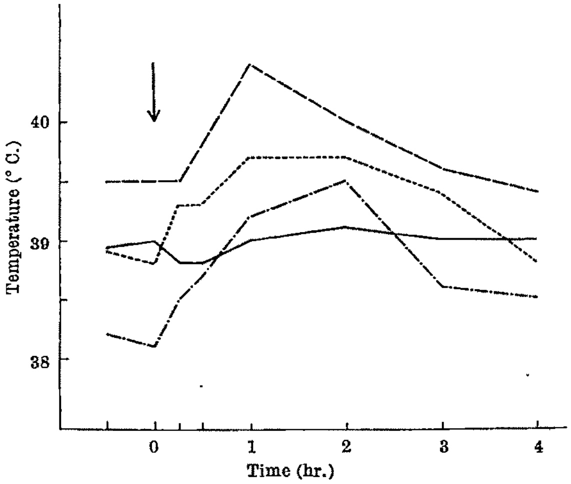

Fig. 1. Rectal temperature changes in rabbits after intravenous administration (arrow) of 20 ml. of sera obtained from: ———, normal rabbit; ......, actively sensitized rabbit injected with 5 μgm. of PPD; —·—·—, actively sensitized rabbit injected with 5 μgm. of PPD, serum being given to endotoxin-tolerant recipient; ----, rabbit passively sensitized with hypersensitive cells, injected with 5 μgm. of PPD

Fig. 1 shows a typical effect of normal serum and serum collected during systemic tuberculin reaction. In all positive cases the result was similar: a short monophasic fever without a latent period. With control sera the increase in temperature was usually not more than 0·2 deg. C.; sometimes the temperature decreased. The difference in temperature produced 1 hr. after injection of serum was taken as the criterion for evaluation of the experiments (Table 1). It is evident that the large majority of control sera gives negative results. The sera collected during the systemic tuberculin reaction in rabbits that had been rendered hypersensitive, actively or passively, gave mostly positive results. These results cannot be ascribed to the effect of non-specific endotoxic substances which are known to be present in non-purified tuberculin[4].

Table 1. APPEARANCE OF FEVER IN RABBITS INJECTED INTRAVENOUSLY WITH FEBRILE AND NON-FEBRILE SERA

The number of negative, moderately positive and positive results is shown. + indicates fever induced; − indicates absence of fever

Characteristics of the sera used			Rise in body temperature in recipients (deg. C.)		
Experimental groups of rabbits	Injected with	Fever response	0–0·3	0·5–0·7	0·8–1·3
BCG sensitized	PPD	+	11	8	9
	PPD	+*	—	1	4
	—	—	10	—	—
Controls	PPD	—	15	1	—
	—	—	14	1	—
Passively sensitized with cells	PPD	+	4	6	3
	—	—	4	—	—
Acceptors of normal cells	PPD	—	6	—	—

* Given to recipients tolerant toward endotoxin.

The fundamental characteristics of an endogenous pyrogen are the ability to induce a short immediate fever and the preservation of this ability on transfer to rabbits tolerant toward endotoxin[1]. Both these points have been demonstrated in present experiments. The results in Table 1 show that an endogenous pyrogen is produced by a reaction between a small amount of purified tuberculin and cells of hypersensitive rabbits, both in actively sensitized rabbits and after transfer of hypersensitive cells into normal recipients.

J. JOHANOVSKÝ

Division of Immunology,
Institute of Biology,
Czechoslovak Academy of Sciences,
Prague.

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Virus-like Particles in chemically induced Carcinoma of the Uterine Cervix

THE ultra-microscope structure of carcinoma cells has been thoroughly studied, but essential differences between neoplastic and normal cells have so far not been established, with the possible exception of so-called 'virus-like particles'[1].

Virus-like particles are reported to occur in mammary carcinoma of mice known to carry the milk factor[2–4] and several groups of investigators interpret these particles as the materialization of the mammary tumour virus. Pitelka *et al.*[5] demonstrated the presence of identical virus-like particles in hyperplastic alveolar nodules of the mammary gland of the *C3H/He CGRL* mouse, a lesion generally considered as a precursor of mammary carcinoma. Howatson and McCulloch[6] described virus-like particles in a transplantable mouse plasma cell tumour which originated in a female *C3H/He* mouse. To the best of our knowledge, these characteristic particles have not been found in chemically induced tumours.

Our material consists of virgin *C3H/A* mice, a number of which has been treated with bi-weekly applications of 3,4-benzopyrene. Invasive cervical carcinoma occurred after forty weeks. Ultra-thin sections of these tumours were examined in the electron microscope. The ultra-morphology of the tumours has been described elsewhere[7]. In a certain number of slides, we found intra- and extra-cellular

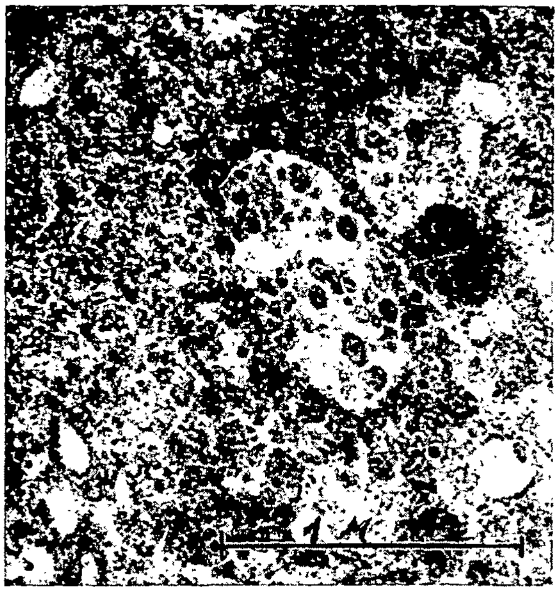

Fig. 1. Virus-like particles gathered into an elliptical cluster in the cytoplasm of a chemically induced cancer cell of the uterine cervix of a mouse

particles morphologically indistinguishable from the virus-like particles described in mammary tumours (Fig. 1).

The particles are almost circular in shape with an external diameter of 500–800 A. The centre is often found empty, but sometimes contains a dense core, 300–400 A. in diameter, surrounded by one or two concentric membranes separated by an interspace of lesser optical density. The number of particles per cell section varies. The corpuscles are scattered through the cytoplasm or gathered into irregular elliptical or circular clusters. Particles may be seen surrounding intra-cytoplasmic vacuoles. Tumour cells heavily laden with particles were often found in the immediate vicinity of others containing no particles whatsoever. The intercellular spaces, large and irregular, often showing deep infoldings of the plasma membranes, may harbour large numbers of virus-like particles. Irregularly shaped inclusions of dense homogeneous material are encountered within the cytoplasm of several neoplastic cells. Scattered throughout the matrix of these amorphous inclusion bodies, varying numbers of characteristically shaped particles may be found.

Virus-like particles have not been discovered in liver, spleen, intestine, colon, breast or pancreas of treated mice.

The presence of virus-like particles in a chemically induced carcinoma of the cervix is puzzling, even though *C3H/A* mice are known to have the milk factor and to be disposed to mammary carcinoma.

For several reasons, it needs a stretch of the imagination to admit that the chemically induced uterus cancer of mice would be caused by a virus. As a matter of fact, in contradistinction with the breast cancer, carcinoma of the cervix scarcely ever occurs spontaneously in mice. Furthermore, polycyclic hydrocarbons can induce tumours in almost any organ of this animal.

We cannot prove, of course, that the particles described are not simply due to casual viral infection, though we do not understand why contamination should remain confined to the cervix. Should casual infection be proved, it still would not have any bearing on the induction of a (necessarily pre-existing) tumour. A hypothesis demanding further investigation is whether these virus-like particles should not be considered as a morphological substratum of the neoplastic reaction, an assumption which applies as well to spontaneous as to experimentally induced tumours. In other words, we wonder whether virus-like particles may not happen to be a result, rather than the cause, of the carcinomatous process.

This investigation was supported in part by a research grant from the Fonds National de Recherche Scientifique.

M. Thiery
M. De Groodt
F. De Rom
M. Sebruyns
A. Lagasse

Gynæcological Department of the
'Centre Anti-cancéreux',
Institute of Histology and
Laboratory of Electron Microscopy,
State University,
Ghent.

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Histochemical Demonstration of A and B Antigens in Platelets

The existence of A, B, AB and O groups in platelets has been shown by Gurewitch and Nelken[1], and confirmed by other authors. This communication deals with the application of fluorescent antibody technique[2] for the investigation of platelet antigens.

Blood samples from A, B, AB and O donors were obtained in 'Complexon III'. The platelets were separated by differential centrifugation and washed twice in phosphate-buffered saline *p*H 7·0. Rabbit and chicken[3] anti-human globulin sera were used for conjugation with fluorescein *iso*thiocyanate (kindly provided by Difco). The conjugation procedure was as follows: to 6 ml. of anti-human globulin serum the following solution was added: saline 6·25 ml.; buffer CO_3-HCO_3 0·5 *M*, *p*H 9·0, 2 ml.; and acetone 1·25 ml. Fluorescein *iso*thiocyanate (25 mgm.) was added directly to the reaction mixture with stirring and stored for 18 hr. in an ice-box. The unconjugated fluorescein was removed by dialysis at 4° C. against 0·15 *M* sodium chloride, 0·01 *M* phosphate buffer *p*H 7·0, for a period of 5–6 days. The third conjugate used in the experiments was a sheep anti-rabbit globulin fluorescein conjugate (a commercial preparation of Sylvana Chemical Co.). All conjugates were heated at 56° C. for 20 min., thoroughly absorbed with washed thrombocytes and red cells and checked for the presence of specific antibodies prior to use. The absorption is a very important step of procedure, since platelets may non-specifically bind the stained protein molecules from unabsorbed conjugates.

Two staining procedures were performed. First, two drops of A, B or AB platelets suspension (approximately 8,000,000 cells per ml.) were mixed with corresponding anti-serum (anti-A, anti-B, or anti-A,B) and left for 2 hr. at 20° C. The cells were then washed three times in buffered saline and to one drop of suspension four drops of chicken (or rabbit) anti-human globulin conjugate were added. The incubation lasted for 90 min. at room temperature followed with one washing of platelets. Finally, the cells were resuspended in glycerol containing 10 per cent buffered saline, and one small drop of suspension was transferred on to a slide and flattened with cover slip. Each suspension was checked for number and conditions of cells with a phase-contrast microscope. Controls for first staining procedure were : (*a*) platelets plus conjugate ; (*b*) platelets from group A plus anti-B serum plus conjugate, and cells from group B plus anti-A serum plus conjugate. The second staining procedure was similar to that already described for leucocytes[4] : (*a*) platelets were exposed to anti-serum as above ; (*b*) the cells were washed and treated with rabbit anti-human globulin serum at 37° C. for 2 hr. (serum absorbed with thrombocytes and red cells was used) ; and (*c*) washed platelets were brought into contact with the sheep anti-rabbit globulin conjugate and incubated for 90 min. at room temperature. Controls for the second procedure were as follows : (*a*) platelets plus conjugate ; (*b*) platelets from group A plus anti-B serum plus conjugate, and cells of group B plus anti-A plus conjugate ; (*c*) cells plus anti-human globulin serum plus conjugate (anti-serum was omitted) ; and (*d*) platelets plus anti-serum plus conjugate (anti-human globulin serum was omitted). A Reichert fluorescent microscope equipped with dark-field condenser and an Osram *HBO* 200 mercury lamp was used. The microphotographs were taken on Agfa 'Fluorapid' film.

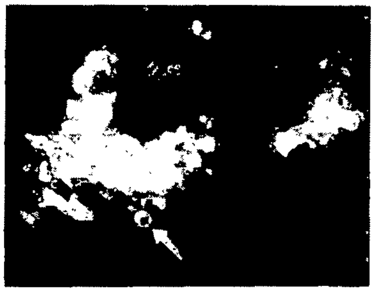

Fig. 1

The results have shown that the positive staining is only obtained when A, B or AB platelets were treated with anti-A, anti-B or anti-AB serum respectively. Thrombocytes from group O exposed to anti-A, anti-B or anti-AB serum did not show the fluorescence. The same holds for all controls. Fig. 1 (× 500) shows brightly stained clumps of platelets from group A treated with anti-A and chicken anti-human globulin conjugate (the arrow shows a stained erythrocyte). Both staining procedures were proved to be useful in demonstrating A and B antigens in thrombocytes. It should be pointed out that the method described here is performed on the cell suspension and includes specific adsorption of all reagents. No fixatives were used. Since we have succeeded in staining leucocytes[4] and red cells[5] specifically using fluorescein-labelled antibodies, it seems that fluorescent antibody technique may be successfully applied in the field of immunohæmatology.

We are indebted to the Institute for Nuclear Sciences, Vinča, for making a fluorescent microscope available for this study.

B. D. Janković
K. Arsenijević

Microbiological Institute,
Belgrade University School of Pharmacy,
Belgrade, Yugoslavia. Dec. 27.

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T2 Phage Infection of 'Protoplasts' obtained by Penicillin Treatment of *Escherichia coli B*

It was observed by Lederberg[1] that cells of *E. coli B*, grown in the presence of penicillin, changed in hypertonic solutions to spherical corpuscles that were readily lysed when transferred to a hypotonic medium. These corpuscles exhibited osmotic characteristics similar to those of various bacterial protoplasts. We have studied the adaptive activity to synthesize β-galactosidase of *E. coli B* 'protoplasts' obtained by penicillin treatment, according to Lederberg's method. We found that the addition of *T*2 phage immediately stops β-galactosidase synthesis, as it does in *E. coli B* cells[2]. The present communication deals with the mechanism of this process.

For the preparation of 'protoplasts' 90 ml. of a culture of *E. coli B*, grown overnight at 37° C. in a nutrient broth similar to 'Difco Penassay', was added to 210 ml. of the same medium containing 20 per cent sucrose, 0·20 per cent magnesium sulphate and 1,000 units/ml. of penicillin. The mixture was shaken for 3 hr. at room temperature. As revealed by phase-contrast microscopy, the above treatment changed 95 per cent of the cells to round corpuscles. The 'protoplasts' thus obtained were centrifuged and resuspended at 1×10^8/ml. in broth containing 0·6 *M* sucrose and 2 per cent serum albumin, and infected with *T*2 phage at 6×10^8/ml. After 5 min. the sample was diluted to 1 : 100 and was shaken at 30° C. in a water-bath. The hundredfold dilution of the samples is very important, not only for inhibiting the re-adsorption of the resulting phage particles, but also because the lysed 'protoplasts' inactivate the free *T*2 particles very quickly. *E coli B* cells, serving as controls, were treated in the same way except for the addition of penicillin. For the determination of phage particles during their multiplication cycle we used the premature lysis method of De Mars[3].

As shown in Fig. 1, under these experimental conditions the *T*2 phage can infect the cells as well as the 'protoplasts' derived from them, and both can synthesize the virus at nearly the same rate. No phage synthesis was observable when the 'protoplasts' were incubated for 10 min. in a hypotonic solution (0·9 per cent sodium chloride) before infection, because of the resulting osmotic lysis.

As in normal bacterial cells the receptors for *T*2 phage are known to be present in the cell wall, the above findings suggest that the treatment with penicillin does not cause general damage to this structure. If it is assumed that the *T*2 phage receptors are bound exclusively to the lipoprotein component of the cell wall[4], the phenomenon observed can readily

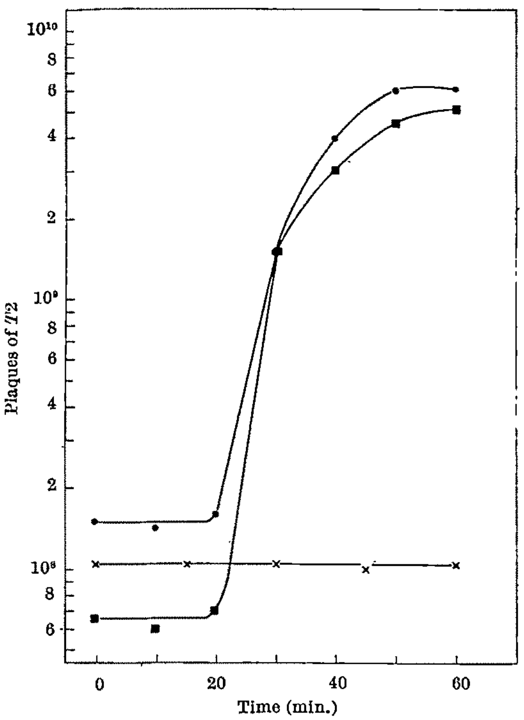

Fig. 1. Multiplication of $T2$ phage. ●—●, In *E. coli B* cells; ■—■, in 'protoplasts'; ×—×, in lysed 'protoplasts'

be explained, as penicillin is supposed to inhibit only the synthesis of the mucocomplex component[5–7] responsible for the rigidity and the actual morphology of the cell wall[8].

We are inclined to think, on the basis of our observations, that certain cell preparations of McQuillen[9] may also have had more or less cell-wall components on their surface.

When accepting the proposed definition for protoplasts[10], the spherical particles obtained from *E. coli B* by penicillin treatment can scarcely be considered as typical, since they are sensitive to $T2$ phage infection, that is, they seem to have the appropriate receptors undamaged on their surfaces.

G. Dénes
L. Polgár

Institute of Medical Chemistry,
University of Budapest. Oct. 21.

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The Inferior Mesenteric Ganglion in Man

The inferior mesenteric ganglion has been studied in the cat by A. J. Harris[1] and in the rabbit by G. Brown and J. E. Pascoe[2]; but in man, however, no full description of the anatomy of the ganglion itself has yet appeared.

A series of 19 stillbirths and neonatal infants, ranging from 7½ months to full term, were dissected after having been injected with embalming fluid through the umbilical vein.

The inferior mesenteric plexus was easily found by tracing down the intermesenteric nerves to their junction with it. The plexus was then dissected very carefully under a powerful lens, the nerves being teased away with a fine dissecting needle until a solid white structure, the inferior mesenteric ganglion, was isolated. In each specimen one or two ganglia were found, variable in size, and although some were small they all could easily be seen with the naked eye. They were in close proximity to the inferior mesenteric artery, being placed on either its left or right side. In three specimens two separate ganglia were found receiving nerves from their respective sides. Branches from the left ganglion tend to run to the distal part of the transverse colon, descending colon and upper part of the pelvic colon; while those from the right one accompanied the parent artery into the pelvic mesocolon to innervate the lower part of the sigmoid colon and upper part of the rectum.

The inferior mesenteric ganglion is a well-defined body capable of isolation and may be said to be a constant structure in man. It is an important relay station in the nerves to the distal part of the large intestine.

Further details of this work will be presented for publication at a later date.

J. A. Southam

Department of Anatomy,
University of Manchester.
Dec. 7.

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A New Leech-infesting Cercaria from Duddingston Loch, Edinburgh

Valvata piscinalis, a common snail in the Duddingston Loch, Edinburgh, was found infected with a new furcocercous cercaria. Of 758 snails examined, 19 were found infected. This cercaria, which is named *Cercaria valvatae* n.sp., develops in long tubular sporocysts forming a tangled mass in the hepatopancreas of the snail. With the proliferation of the germ balls the tubular sporocyst becomes constricted into sausage-shaped swellings containing developing cercariae. The abbreviated specific diagnosis of *Cercaria valvatae* n.sp. (Fig. 1) is as follows.

Body, oval without eye-spots, 0·18–0·22 mm. long and 0·084 mm.–0·1 mm. broad. Anterior end beset with transverse rows of minute spines. Oral organ protrusible, 0·036 mm. × 0·025 mm. to 0·045 mm. × 0·03 mm.; divisible into two parts, anterior part thin, posterior part muscular. Ventral sucker equatorial or post-equatorial, highly muscular, protrusible, 0·027 mm. × 0·025 mm. to 0·03 mm. × 0·028 mm. Prepharynx small, pharynx globular, 0·014 mm. diameter, œsophagus 0·03 mm. long. Intestinal cæca extend slightly posterior to the ventral sucker. Penetration glands 3 pairs, bilobed, granular, posterior to ventral sucker, opening by long ducts at the base of oral organ. Excretory bladder, ovoid; flame cells six pairs, five in the body and one in the tail stem. Tail stem 0·16–0·23 mm. long. Caudal furci 0·19 mm.–0·21 mm. long, not provided with fin or membrane.

Of the furcocercous cercariae described from Great Britain this cercaria comes nearest to *Cercaria* F_1[1], *Cercaria Y*[2], *Cercaria micromorpha*[3] and *Cercaria pygocytophora*[4], but differs from these in the number of either the penetration glands or the flame cells.

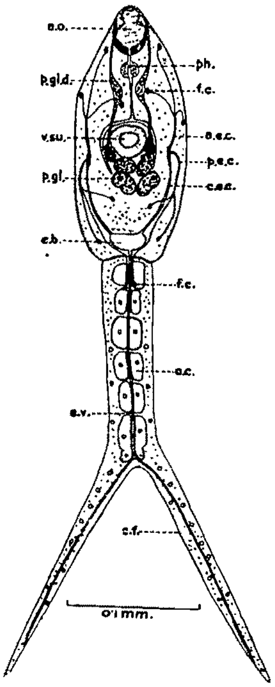

Fig. 1. *Cercaria valvatae* n.sp. showing morphological details

It is also distinct, besides other features, in the nature and number of penetration glands or flame cells from *Cercaria cristata* and *Cercaria longiremis* described from *Valvata piscinalis* from the Continent by Wesenberglund[5] as also from the cercariae of *Aptemon gracilis* and *Cotylurus cornutus* producing tetracotyle larvæ in leeches described by Szidat[6] and the American *Cercaria burti*.

A large number of infection experiments were tried with a variety of animals to find out the intermediate host of *Cercaria valvatae* n.sp. This revealed the quick penetration of this cercaria within 2–3 min. into the body of the leech *Helobdella stagnalis*, followed by casting of the furcocercous tail and entry into its hæmo-cœlomic system. In the next 3–4 days the cercarial structures were lost and in 7–8 days new structures developed and a cyst was secreted around the tetracotyle. The cysts were clearly seen in the body of the leech at this stage (Fig. 2). About 28 days were required between the cercarial penetration and the formation of a complete tetracotyle.

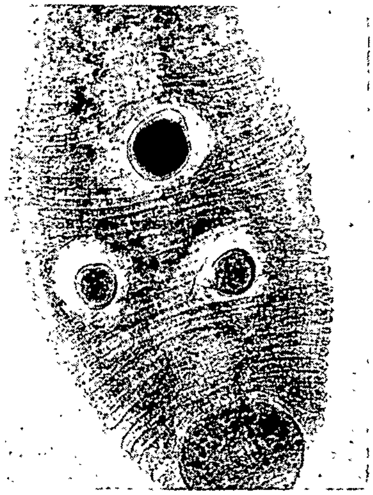

Fig. 2. Cysts of tetracotyle in the body of the leech

I am grateful to (the late) Prof. James Ritchie for providing facilities for this work at Edinburgh.

M. B. LAL

Department of Zoology,
The University, Lucknow.
Oct. 10.

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GENETICS

Linkage of Polygenes controlling Size of Ascospore in *Neurospora crassa*

IT has been shown in earlier work[1,2] that the size of ascospore in *Neurospora crassa* is controlled by a polygenic system. In the course of experiments designed to give further information on this system, results were obtained which indicate that a part of the polygenic system is linked with the albino locus on chromosome I.

The strains used were 232·1, 232·2, 232·3 and 232·4, all of which are albino (*al*-2), large-spored strains comprising a 4-spored ascus obtained from the sixteenth generation of selection for increased ascospore size[2].

These strains were crossed to the appropriate wild type and the crosses incubated at 25° C. 50 ascospores were randomly isolated from each cross. The F_1 ascospores were normal in size. The isolates thus obtained were each back-crossed to the large-spored parent. This gave a total of 29 crosses in which albino F_1 strains were back-crossed and 48 crosses in which non-albino F_1 strains were back-crossed. A sample of 50 ascospores from each cross was measured. The results are presented in Table 1.

The majority of back-crosses involving albino F_1 strains had mean ascospore-lengths in the range 19·42–22·30, while the majority of back-crosses involving non-albino F_1 strains had mean ascospore lengths in the range 17·26–18·92. The difference, 1·02 units, between the mean ascospore-length of the two groups of back-crosses is highly significant ($P < 0·001$ per cent), which indicates that some of the genotypic material controlling size of ascospore segregated in association with the albino locus. That is, there is linkage between this genotypic material and the albino locus. This genotypic material is responsible for approximately one-sixth of the total

Table 1. BACK-CROSSES OF *al* AND al^+ F_1 STRAINS TO LARGE-SPORED PARENTS

	al F_1 strains	al^+ F_1 strains
No. of back-crosses with mean in range 17·26–18·92	2	43
No. of back-crosses with mean in range 19·42–22·30	25	5
No. of intermediates	2	0
Total No. of back-crosses	29	48
Mean ascospore length*	19·84	18·82
Standard deviation of mean	0·019	0·033

For difference between means, $t = 13·077$; $P < 0·001$ per cent.
* 1 unit = 1·72μ.

response (about 6 units) to selection for increased ascospore size obtained over sixteen generations[2].

From Table 1 it can be seen that two out of the 29 *al* F_1 strains, when back-crossed, gave a mean ascospore-length in the 17·26–18·92 range, and five of the 48 *al*+ F_1 strains, when back-crossed, gave a mean ascospore-length in the range 19·42–22·30. It is reasonable to regard these exceptions as due to crossing-over occurring between the albino locus and the site of the genotypic material controlling this part of the response to selection for increased ascospore size. If this is so, then this genotypic material is located about 9 cM. from the albino locus, calculated on the assumption of seven recombinations in a total of 75 back-crosses. As yet it is not possible to say whether this site is proximal or distal to the albino locus.

The length of ascospore of the majority of back-crosses fell into one or the other of two distinct classes. There were, however, two *al* F_1 strains where the mean ascospore length of the back-cross was intermediate between the two classes. The mean ascospore-lengths of these two back-crosses were 19·18 and 19·26. These intermediate cases were probably due to the segregation of the genotypic material controlling the rest of the response to selection for increased ascospore size. These two intermediate cases have not been included in the approximate estimation of the degree of linkage of the genotypic material to the albino locus.

Further work is being carried out in order to establish more precisely the position of this part of the genotypic material controlling ascospore size. This work will be reported in more detail elsewhere.

B. T. O. Lee
J. A. Pateman

Botany School,
University of Melbourne.
Dec. 22.

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Ratio of Visible to Lethal Mutations produced in *Drosophila* by Phenylalanine Mustard

The present experiments were undertaken in order to see whether we could confirm the high visible mutation-rate relative to the lethal mutation-rate induced in *Drosophila* by phenylalanine mustard as compared with X-irradiation, reported by O. G. and M. J. Fahmy[1]. Since this high visible rate would imply (1) the existence of loci specifically concerned with visible mutations and as a group qualitatively different from non-visible loci and (2) a specific effect of the agent on such loci, it seemed important that this work be repeated.

Wild-type males of *Drosophila melanogaster*, 12–30 hr. old, were injected intra-abdominally with approximately 0·001 ml. of a 10^{-2} *M* suspension of *p*-N-di(chloroethyl)amino - phenylalanine(phenylalanine mustard) in distilled water or in 0·75 per cent saline, the amount injected being sufficient to cause noticeable swelling of the abdomens. The survivors were tested for sex-linked recessive lethal and visible mutations by the Muller-5 technique. An average of 9–10 daughters from each treated or control male was tested for mutations, several of the sons of each female being carefully scrutinized for visible mutations. In some experiments all the sons of each female were examined for visible mutations with the expectation of detecting delayed mutants and also mutants of such weak expression that not all the F_2 red-eyed sons would show the mutant trait. Table 1 shows the results of these tests, as well as results from control males into which distilled water or 0·75 per cent saline only was injected (distilled water versus saline having been found to have no significant influence on the rate of mutation).

Although the mutagenic effectiveness of phenylalanine mustard in our experiments is shown by the lethal-rate in Table 1, no visible mutations were found. This fact is difficult to reconcile with the report of the Fahmys[1] that from phenylalanine mustard-treated males 381 recessive visible mutations were found among 25,622 'treated X-chromosomes' in a series giving 7 per cent of lethals. After allowance is made for the lower lethal mutation-rate in our experiments, we should have recovered at least 6 visible mutants if we had found visible mutations in as high a proportion to lethals as the Fahmys did, a number that differs significantly from the number (0) found by us. However, this number does not differ significantly from the 2 or 3 visibles that would have been expected if X-rays had been used as the mutagenic agent, since the ratio of visible to lethal mutations found previously by various workers using the same type of genetic technique is in the range of 1 : 7 to 1 : 10. The report of the Fahmys[1] that phenylalanine mustard produces a ratio of visible to lethal mutations of nearly 3 : 10 (279 visibles in a population containing 999 lethals) is not confirmed by our work, since our finding of no visibles does differ significantly from an expectation of finding 2 : 7 ($P = 0{\cdot}05$) or 2 : 10 ($P = 0{\cdot}02$). Thus the chemical used could not be as much as twice as effective as X-rays in producing visibles as compared with lethals.

In explanation of the discrepancy between our results and those of the Fahmys, it should be mentioned that the Fahmys used a method of detecting visible mutations different from that used by us and by X-ray workers in general, in that they looked particularly for their visibles in suspected lethal or semi-lethal cultures, examining these cultures until the very end of their hatching period (though this

Table 1

Agent	No. of males treated		No. of chromosomes tested (no. of lethals in parenthesis)		Mutation-rate	
	Brood 1 (0–6 days)	Brood 2 (7–12 days)	Brood 1 (0–6 days)	Brood 2 (7–12 days)	Lethal	Visible
Phenylalanine mustard	121	65	1,056 (15)*	742 (12)*	1·5 ± 0·3%	0
Distilled water or 0·75 per cent saline	113	90	1,048 (3)†	831 (1)	0·2 ± 0·1%	0

* Two lethals were obtained from each of three treated males and have been considered as being of common origin in calculating the error of the mutation-rate, in accordance with Muller's method of statistical treatment (ref. 2).

† One semi-lethal.

procedure is only mentioned in passing on one of their earlier publications[3] and came to our attention after the completion of the present experiments). As is well known, the few surviving males in semi-lethal cultures are often abnormal. The Fahmys's 'visible' rate, relative to complete lethals, would therefore be very high, since most workers would include semi-lethals of very low viability with the complete lethals rather than with visibles. Moreover, the exclusion of the semi-lethals from the lethal class would further increase the visible rate relative to the lethal rate.

In conclusion, it might be pointed out that a lethal is often a visible of very low viability and that the distinction between 'lethals' and 'visibles' is really a matter of convenience. On general grounds, therefore, it is scarcely to be expected that any mutagenic agent should specifically produce visible effects, as contrasted to lethal.

This work has been supported by a grant from the American Cancer Society.

L. S. Altenburg
Edgar Altenburg

The Rice Institute,
Houston, Texas.

Oct. 1.

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A Position-Effect Explanation of Gene Conversion

Gene conversion was the name given by Winkler[1] to the transformation in a heterozygote of a + allele into a mutant allele, or of one mutant into another. He intended to explain recombination and crossing-over through digenic conversion of allele A into a in one chromosome and simultaneously of a into A in its homologue. Monogenic conversion, in only one chromosome, should also be possible, but this would not easily be distinguished from mutation. More recently, conversion has been used only in the monogenic sense[2] in which it is demonstrated chiefly through tetrad analysis from heterozygotes Aa when the expected Mendelian segregation of $2A : 2a$ is not obtained.

However, tetrads with three mutants and 1 + spores may be produced also from intragenic cross-over, that is, cross-over which takes place within a gross locus subdivided into sub-loci corresponding to sub-alleles or pseudo-alleles[3]. Typical intragenic cross-over has been demonstrated, for example, in the adenine-3 gross locus of *Neurospora*[4]. In a gene b subdivided into sub-alleles b_1 and b_2, the cross of a b_1 by a b_2 strain may be represented as $b_1 + \times + b_2$, and this will give a tetrad $b_1 +, + +, b_1b_2, + b_2$. If no distinction is made between the phenotypes of b_1 and b_2, the apparent result is b, +, b, b, or three mutants to 1 +. This is apparent conversion, which may be separated from true conversion only when sub-alleles are distinguishable.

Variegated conversion—the production of variegation in a heterozygote, not attributable to any apparent chromosome aberrations—has been reported to occur in *Oenothera*[5], but further analysis will be necessary before it can be generally admitted. True conversion, not associated with variegation, may be called stable conversion or transmutation[6]. This is at present the most important form of conversion since it has been plainly demonstrated to occur in *Neurospora*[7,8], and very probably in *Saccharomyces*[2,9] and some other species. Its importance stems from the fact that it constitutes a proved exception to Mendelian theory.

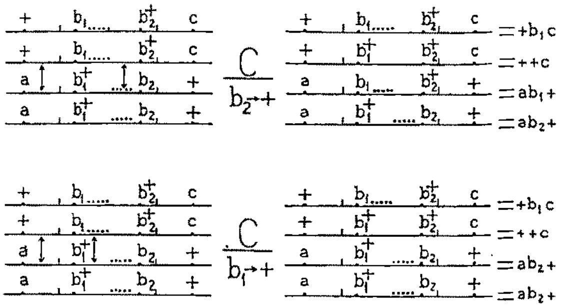

Fig. 1. Conversion of b_2 into + and of b_1 into +, corresponding respectively to asci 1 and 4 of Mitchell (ref. 7). Conversion results from relocation, by cross-over, of sub-alleles b_1 or b_2 adjacently to a different intermediary segment between them, which caused position effect (dotted) now reverting to +

Two types of explanations have been advanced for true, stable conversion: namely, a differential and compensatory reduplication, for example, the + allele reduplicating twice while allele a does not reduplicate[7]; and a transfer of chemical groups from one allele to the other, so as to result in a kind of mutation. The transfer might also be effected as a dislocation of groups similar to a kind of Thompson's episomes[10], or through enzymes and during gene reduplication[8], or by means of a transductor[11], reminiscent of transduction phenomena in bacteria. These are *ad hoc* hypotheses which lead neither to generalization nor to the possibility of prediction. An explanation is offered here, based on mechanisms known to operate at other levels, and which it is only necessary to extend to the intragenic level. Stable conversion is explained by intragenic cross-over which, by separating sub-loci, restores the intragenic position effect that caused the mutant phenotype. Fig. 1 shows how the explanation works for two of the asci in the clearly demonstrated case of *Neurospora*[7]. For simplicity of lettering, the loci studied by M. B. Mitchell[7] will be designated a for pyrimidine-1, b_1 for pyridoxine pH-sensitive, b_2 for pyridoxine non-pH sensitive, c for colonial. Other markers, located far from the b gross locus, are not necessary for this explanation. b_1 and b_2 are sub-alleles. Between them will be a segment of the b gross locus which causes position effect (see also legend of Fig. 1). Other conversion-asci are similarly explained. The explanation implies negative interference[3].

Details of this work will be published elsewhere.

J. A. Serra

Institute of Zoology,
Faculty of Science,
Lisbon.

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[4] Giles, N., DeSerres, F., and Barbour, E., *Genetics*, **42**, 608 (1957).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 9

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Sir Charles Darwin, F.R.S.: "Darwin the Traveller".

Tuesday, March 10

Society of Chemical Industry, Agriculture Group (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Potash Meeting.

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "The Laplace Transform—a Tool for the Electrical Engineer" opened by Mr. A. C. Sim.

Institute of Information Scientists (at the Berners Hotel, 10 Berners Street, London, W.1), at 6 p.m.—Symposium on "Russian Technical Information". Speakers: Mr. R. Sewell, Mr. A. Post and Dr. D. J. Urquhart.

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. R. F. Jones: "Water and Ice in the Atmosphere".

Wednesday, March 11

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. D. C. Martin: "Some Achievements of the International Geophysical Year".

Palæontological Association (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting. Prof. Gerhard Regnéll (University of Lund): "The Lower Palæozoic Echinoderm Faunas of the British Isles and Balto-Scandia".*

University of London (in the Hatton Lecture Theatre, Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. C. P. Whittingham: "The Development of Experimental Botany"* (Inaugural Lecture).

Society of Chemical Industry, Food Group (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Dr. G. C. Whiting: "Organic Acid Metabolism in Cider Fermentations"; Dr. Jean Scott and Mr. E. J. Rolfe: "Vitamins of the *B* Complex in Cod and the Effect on them of Dehydration".

Thursday, March 12

Physical Society, Low Temperature Group (at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 9.30 a.m.—All-day Symposium on "Hydrogen Liquefaction and Associated Topics".

Royal Society (at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Discussion on "The 'Ear' Under Water" opened by Prof. O. Lowenstein, F.R.S.

Imperial College (in the Department of Geology, Prince Consort Road, London, S.W.7), at 3.30 p.m.—Prof. Gerhard Regnéll (University of Lund): "The Lower Palæozoic Rocks of Sweden".*

Institution of Electrical Engineers, Utilization Section (joint meeting with the London Graduate and Student Section, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. A. P. Foster: "Coalmining and Electricity"; Mr. P. D. House: "Electric Drives in the Paper Industry"; Mr. M. J. L. Willison: "Standardization and Simplification of Switchgear".

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Monsieur l'Ingénieur Général de l'Air Noël Daum: "The Griffon and the Prospect of Combining the Turbo-Ram-Jet Engine for Propulsion of Aeroplanes at High Speeds" (Twelfth Louis Bleriot Lecture).

Plastics Institute (at the Wellcome Foundation Building, Euston Road, London, N.W.1), at 6.30 p.m.—Mr. S. P. Chambers: "International Competition in the Chemical Industry" (Tenth Annual Lecture).

Antiquarian Horological Society (at the Science Museum, South Kensington, London, S.W.7), at 7 p.m.—Mr. W. J. Gazeley: "The Lever Escapement".

Royal Institute of Chemistry (joint meeting with the Chelsea College of Science and Technology Chemical Society, at the Chelsea College of Science and Technology, Manresa Road, London, S.W.3), at 7 p.m.—Prof. E. D. Hughes, F.R.S.: "Reaction Mechanisms".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Sir Eric Rideal, F.R.S.: Irving Langmuir Memorial Lecture.

Friday, March 13

Institution of Mechanical Engineers (in conjunction with the British Nuclear Energy Conference, at Central Hall, Westminster, London, S.W.1), at 9.30 a.m.—Lecture Symposium on the Geneva Conference.

British Psychological Society, Occupational Psychology Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. A. K. Rice: "Systems of Organisation".

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Papers by Dr. O. J. Eggen, Dr. A. R. Sandage and Prof. F. Hoyle, F.R.S. Dr. H. E. Butler: "Possibilities of Astronomical Research with British Rockets".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. H. M. Finniston: "On Bombarding Solids with Neutrons".

Saturday, March 14

British Society for the History of Science (in the Auditorium of the Wellcome Building, Euston Road, London, N.W.1), at 10.15 a.m.—Symposium on "Darwin, Evolution and Modern Life". (Darwin Symposium to commemorate the Centenary of the publication of "The Origin of Species", 1859.)

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Laboratory Steward (over 21 years of age, previous experience in a biological, medical, biochemical or chemical laboratory, and preferably experience in the preparation of biological materials, and in photography) in the Department of Botany—The Registrar, University College, Singleton Park, Swansea (March 14).

Post-Doctoral Fellow in the Department of Organic Chemistry, for work on metabolites of marine micro-organisms—The Registrar, The University, Liverpool (March 14).

Tutor or Lecturer (woman, with special qualifications in either experimental or theoretical physics) in Physics—The Treasurer, Somerville College, Oxford (March 14).

Lecturers (2) (one Grade II and one Grade III) in the Department of Mechanical Engineering—The Registrar and Secretary, The University, Bristol (March 16).

Lecturer (with special qualifications in pure mathematics) in Mathematics—The Registrar (Room 22, O.R.B.), The University, Reading (March 19).

Lecturer (with experience in the use of digital computers and qualified to give lectures in numerical analysis or the principles and details of programming) in the Computing Laboratory—The Secretary of University Court, The University, Glasgow (March 20).

Physicist, Principal grade (with wide experience of hospital physics)—The Clerk to the Governors, St. Thomas's Hospital, London, S.E.1 (March 21).

Lecturer (preferably with experience in the design of electrical plant or control systems) in Electrical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (March 23).

Assistant Lecturers (2) in the Department of Zoology—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (March 31).

Chair of Biology in Monash University, Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (March 31).

Assistant in Statistics—The Secretary, The University, Aberdeen (April 4).

Junior Research Fellow in the Natural Products Research Unit, Chemistry Department, University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 4).

Research Fellow (with a Ph.D. degree or equivalent research experience) in the Chemistry Department, for work on absorption from the liquid phase by carbon absorbents, in collaboration with Dr. J. J. Kipling—The Professor of Chemistry, The University, Hull (April 6).

Assistant Physicist (with experience in electronics) at Auckland Hospital, New Zealand, for duties mainly concerned with a linear accelerator—The High Commissioner for New Zealand, New Zealand House, 415 Strand, London, W.C.2 (New Zealand, April 9).

Lecturer in Mathematics—The Secretary, The University, Aberdeen (April 11).

Reader in Agricultural Economics in the Newcastle Division of the University—The Registrar, University Office, 46 North Bailey, Durham (April 11).

Lecturers in Experimental and Theoretical Physics—The Secretary of University Court, The University, Glasgow (April 15).

Senior Lecturer in Biochemistry at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 15).

Assistant Lecturer or Lecturer (preferably with some experience in radiochemical techniques) in Inorganic Chemistry—The Registrar, The University, Nottingham (April 18).

Curator (with an approved university degree in science or equivalent and some experience in the taxonomy of vertebrates) of Mammals at the National Museum, Melbourne, Australia, to take charge of the mammal collections, undertake field work, conduct research upon mammals, and to assist in such other Museum matters as may be required—The Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2 (April 25).

Assistant Professor (with postgraduate education equivalent to the Ph.D. in plant pathology and related fields) of Plant Pathology in the Department of Plant Science—Head of the Department of Plant Science, University of Alberta, Edmonton, Alberta, Canada (May 1).

Associated Electrical Industries Fellow in the Department of Engineering, for research in any branch of engineering—The Secretary-General of the Faculties, The University, The Old Schools, Cambridge (May 31).

Assistant Director (with a good science degree, preferably with some knowledge of genetics and/or statistics, and also a knowledge of at least two foreign languages) of the Bureau of Animal Breeding and Genetics, King's Buildings, West Mains Road, Edinburgh 9, Scotland—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (June 14).

John Thompson and Tube Investments Research Scholars (graduates of Sheffield or any other approved university), for research in mechanical engineering—The Registrar, The University, Sheffield (June 20).

Hydrologist (between 23 and 45 years of age, with a degree in civil engineering and at least two years subsequent experience, or a degree in applied science with some direct experience in applied hydrology) in the Ministry of Works, Kenya, for duties which include the measuring of river flows, assessment of flood discharges, rainfall-runoff, studies and assessment of ground-water resources, their recharge and depletion—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.112/7/01/T.

Lecturer (preferably with experience of digital electronic circuit techniques) for teaching and research in Control Engineering, to work with a group concerned with the development of statistical and digital methods in relation to all types of electrical, hydraulic and pneumatic controls—Head of the Electrical Engineering Department, Imperial College, Exhibition Road, London, S.W.7.

Lecturer (with experience in the development of electrical machines, and preferably an interest in combinations of machines and rectifiers for high power outputs) in Electrical Engineering—The Head of the Electrical Engineering Department, Imperial College, Exhibition Road, London, S.W.7.

Master (with a good degree, and preferably a bachelor) to teach Physics to Advanced and Scholarship Level—The Headmaster, Ampleforth College, York.

National Research Council Postdoctoral Fellow in Pathology, Mycology, Physiology or Cytology; and a Postgraduate Fellow for the study of micro-organisms involved in cellulose decomposition—The Head of the Department of Botany, University of Western Ontario, London, Canada.

Physicist (honours graduate), to work on radiation effects in solids—Prof. W. R. Ditchburn, Physics Research Laboratory, The University, Upper Redlands Road, Reading, Berks.

Second Technician (with A.I.M.L.T. or National Certificate in Chemistry or equivalent qualifications and experience) in the Cardiac Laboratory, for biochemical investigations—The Director of Pathology, Royal South Hants Hospital, Southampton.

Senior Lecturer or Lecturer (graduate in pharmacy, and actively interested in research) in Pharmacology in the Department of Pharmacy—The Registrar, Bradford Institute of Technology, Bradford 7.

Senior Lecturer (with a university degree or equivalent and a sound theoretical and applied knowledge of electronics) in Medical Engineering (Electronics)—The Dean, Postgraduate Medical School of London, Ducane Road, London, W.12.

Senior Scientific Officers, Scientific Officers and Research Fellows (with a first- or second-class honours degree, an interest in high-energy plasma physics and preferably experience with microwave techniques) in a new group investigating thermonuclear experiments utilizing the injection of pre-accelerated particles into magnetic fields with mirror geometry—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2177/34.

University Demonstrator in Biochemistry—The Administrator, Department of Biochemistry, The University, South Parks Road, Oxford.

Zoologist (with postgraduate training in ethology), to undertake research into the feeding behaviour of wildfowl—The Assistant Director (Research), The Wildfowl Trust, Slimbridge, Gloucestershire.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Bird Migration, Vol. 1, No. 1 (December, 1958). Pp. 40. Published twice yearly in December and July. (Oxford: British Trust for Ornithology, 1958.) 2*s*. 6*d*. [11

National Research Development Corporation. Report and Statement of Accounts for the year 1st July, 1957, to 30th June, 1958. Pp. ii+28. (London: H.M. Stationery Office, 1958.) 1*s*. 6*d*. net. [11

Ealing Public Libraries. Selborne Society Library: a Catalogue of MSS. Books and Periodicals devoted to Gilbert White and Natural History. Pp. 34. (Ealing: Borough Librarian, Central Library, 1958.) [11

General Register Office. The Registrar General's Quarterly Return for England and Wales—Births, Deaths and Marriages; Infectious Diseases; Weather; Population Estimates—No. 439, 3rd Quarter, 1958. Pp. 34. (London: H.M. Stationery Office, 1958.) 2*s*. net. [11

Review of Coal Tar Technology, January—June, 1958. (Vol. 10, Part 1.) Pp. ii+86. (Gomersal, Leeds: Coal Tar Research Association, 1958.) 10*s*. [11

Report of the Frederick Soddy Trust, September, 1958. Pp. 16. (Hove 3, Sussex: The Trustees, Frederick Soddy Trust, 1958.) [11

Planning, Vol. 24, No. 429 (19 September, 1958): Paying for the Railways. Pp. 277–308. (London: Political and Economic Planning, 1958.) 3*s*. 6*d*. [11

Ciba (A.R.L.), Ltd. Technical Notes, No. 192 (December, 1958): Adhesives in Sailplane Building. Pp. 8. (Duxford: Ciba (A.R.L.), Ltd., 1958.) [11

The World of Wool, 1957–58: The Annual Review of the International Wool Secretariat and the Wool Bureau Incorporated. Pp. 102. (London: International Wool Secretariat; New York: Wool Bureau Incorporated, 1958). [11

The Royal Society. British National Committee for the International Geophysical Year. Some International Geophysical Year Achievements: an Interim Statement issued at the close of the Observational Phase of the International Geophysical Year. Pp. i+16. (London: The Royal Society, 1958.) [11

Department of Scientific and Industrial Research. Estimates of Resources Devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955. Pp. 50. (London: H.M. Stationery Office, 1958.) 3*s*. net. [11

Report of the Nature Conservancy for the year ended 30th September, 1958. Pp. vi+119+14 plates. (London: H.M. Stationery Office, 1958.) 6*s*. 6*d*. net. [11

Colonial Research, 1957–1958: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Science Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 347. (Cmnd. 591.) (London: H.M. Stationery Office, 1958.) 14*s*. 6*d*. [11

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1958. No. 4: The Chemistry of Dinitrogen Tetroxide: The Acid-base System as the Basis of Reactivity. By Dr. Peter Gray. Pp. ii+36. 4*s*. 6*d*. net. No. 5: Recent Progress in the Chemistry of Dyes and Pigments. By Prof. W. Bradley. Pp. ii+94. 9*s*. net. (London: Royal Institute of Chemistry, 1958.) [11

Ministry of Power: Safety in Mines Research Establishment. Safety in Mines Research, 1957: Thirty-sixth Annual Report. Pp. 81+4 plates. (London: H.M. Stationery Office, 1958.) 5*s*. net. [11

Other Countries

The Nucleus, Vol. 1, No. 1 (June, 1958). An International Journal of Cytology and Allied Topics. Pp. 152. Published twice a year. Annual subscription: Rs. 46.00; 10.50 U.S. dollars. Single issues: Rs. 23.00; 5.25 U.S. dollars. (Calcutta: Dr. A. K. Sharma, Editor, Botany Department, The University, 1958.) [11

Modern Development in Plant Physiology: Report of Seminar held August 26th to 30th, 1957. Edited by P. Maheshwari. Pp. xi+170. (Delhi: Botany Department, The University, 1958.) [11

Indian National Scientific Documentation Centre. Insdoc Report, 1957–58. Pp. ii+22. (New Delhi: Indian National Scientific Documentation Centre—National Physical Laboratory of India, 1958.) [11

Tokyo Astronomical Observatory. Tokyo Astronomical Bulletin. Second Series. No. 103: Meridian Observation of Right Ascension of Equatorial Stars made with Repsold Transit Instrument—Preliminary Results. No. 13: (July–December, 1956.) By Kônosuke Tuzi. Pp. 1107–1140. No. 104: Meridian Observation of Right Ascension of Moon's Limb made with Repsold Transit Instrument. Report No. 2: (January–December, 1956.) By Kônosuke Tuzi and Kiyoshi Nagane. Pp. 1141–1151. No. 105: Polar Tube Observations during 1957. By N. Sekiguchi and J. Matsumoto. Pp. 1153–1154. No. 106: A Receiving Equipment especially designed for the Detection of Doppler Shift in received Signals. By S. Iijima, Y. Ohki and I. Oguma. Pp. 1155–1163. No. 107: Meridian Observations of the Right Ascension of Minor Planets during the year 1957. By S. Nakano, H. Yasuda and H. Hara. Pp. 1165–1166. No. 108: Meridian Observations of the Right Ascensions of the Moon and Planets during the year 1957. By S. Nakano, H. Yasuda and J. Hara. Pp. 1167–1172. (Tokyo: Tokyo Astronomical Observatory, 1958.) [11

Comptes Rendus des Travaux du Laboratoire Carlsberg. Vol. 31, No. 6: Pinocytosis of Inorganic Salts by *Amoeba Proteis* (*Chaos Diffluens*). By Cicily Chapman-Andresen. Pp. 77–92. 2 kr. 40 øre. Vol. 31, No. 7: Cryptococcus Terricolus Nov. Spec., a New Yeast Isolated from Norwegian Soils. By T. A. Pedersen. Pp. 93–103. 1 kr. 90 øre. (Copenhague: Danish Science Press, Ltd., 1958.) [11

India: Council of Scientific and Industrial Research. Central Fuel Research Institute—Report of the Director for the year 1956–57. Pp. v+71. (Jealgora, Dhanbad, Bihar: Central Fuel Research Institute, 1957.) [11

Smithsonian Institution: National Collection of Fine Arts. Henry Ward Ranger Centennial Exhibition, 1858–1958. Pp. 30. (Washington, D.C.: National Collection of Fine Arts, Smithsonian Institution, 1958.) [11

Smithsonian Institution: Bureau of American Ethnology. Bulletin 168: The Native Brotherhoods: Modern Intertribal Organizations on the Northwest Coasts. By Philip Drucker. Pp. iv+194. (Washington, D.C.: Government Printing Office, 1958.) 1 dollar. [11

Smithsonian Miscellaneous Collections. Vol. 135, No. 1: The Customs and Religion of the Ch'iang. By David Crockett Graham. Pp. vii+114+16 plates. (Publication 4300.) (Washington, D.C.: Smithsonian Institution, 1958.) [11

Annals of the New York Academy of Sciences. Vol. 76, Article 3: Screening Procedures for Experimental Cancer Chemotherapy. By Chester Stock and 77 other authors. Pp. 409–970. (New York: New York Academy of Sciences, 1958.) 5 dollars. [11

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 39 (November, 1958): Widows Increasing in Number. Hazards in Plural Birth. Proportion of Women in Population Increasing. Accident Death Toll in Canada. Pp. 12. (New York: Metropolitan Life Insurance Company, 1958.) [11

The Gardens Bulletin, Singapore. Vol. 16 (1st August, 1958): Bamboos of Malaya. By R. E. Holttum. Eugleninae of Malaya. By G. A. Prowse. A Revision of the Malayan Myristicaceae. By J. Sinclair. Pp. 472+14 plates. (Singapore: Botanic Gardens, 1958.) 25 Malayan dollars. [11

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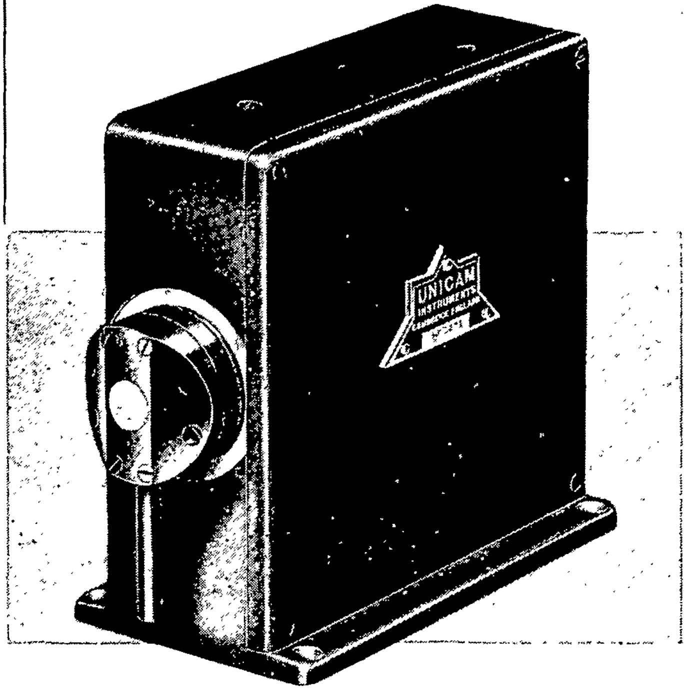

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CsI	„ „ „ 45 μ — 50 μ.
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*KRS-5	„ „ „ 35 μ.

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RESEARCH IN THE UNDER-DEVELOPED TERRITORIES

"COLONIAL Research" continues to expand, although the report for 1957–58* is only some 25 pages larger than that for 1956–57. Apart from the brief annual report on Colonial research from the Colonial Research Council, it contains the thirteenth annual reports of the Committee for Colonial Agricultural, Animal Health and Forestry Research, the Colonial Medical Research Committee, the fourteenth annual report of the Colonial Social Science Research Council, the eleventh annual reports of the Colonial Economic Research Committee and the Colonial Pesticides Research Committee, the fifth annual report of the Colonial Products Council, the third annual report of the Colonial Road Research Committee and reports from the Colonial Fisheries Advisory Committee, the Tsetse Fly and Trypanosomiasis Committee and the Director of the Anti-Locust Research Centre covering the same period. There is also a report dealing with research matters such as building and housing research, the Falkland Islands Dependencies Survey, geodetic and topographical surveys, geological surveys, industrial and engineering research, and meteorology and water pollution research which are not covered by the accompanying reports of the specialist advisory bodies.

Some of these reports include as appendixes reports from Colonial or overseas bodies such as the East African Institute of Social Research, the Nigerian Institute of Social and Economic Research, the Rhodes–Livingstone Institute and the Institute of Social and Economic Research in the University College of the West Indies. There is also fully displayed the way in which the work in some fields can be linked with that of institutions in Britain, such as the Commonwealth Institute of Entomology, the Commonwealth Mycological Institute, Rothamsted Experimental Station, the Long Ashton Research Station, the Field Station at Silwood Park of the Imperial College of Science and Technology, the Unit of Experimental Agronomy of the Agricultural Research Council, and the Building Research Station of the Department of Scientific and Industrial Research. Nor is the impressive list of institutions mentioned in this publication exhaustive, for the recent report of the Nature Conservancy refers to help given by that body, notably in relation to a proposal to establish in Kenya a unit for research on wild fauna, and to the solution of controversy in Tanganyika over the reconciliation of practical problems and the scientific objectives of conservation in the Serengeti plains and the Crater Highlands. The Government's revised proposals here were closely guided by an ecological survey of the area undertaken by Prof. W. H. Pearsall on behalf of the Conservancy.

"Colonial Research 1957–58" thus provides an impressive, but even so, not exhaustive, picture of the effort which Britain is putting into research in the under-developed countries of the Commonwealth; and although the magnitude of that effort, either in terms of finance or of man-power, is not discussed directly, it is apparent that the demand for trained man-power is likely to have a far greater effect on Britain's limited resources than the demands of the under-developed countries for technical assistance have had in the United States, where it has already been cited as a contributory factor in the man-power shortage. The twenty-six new appointments made during the year brought the total complement of the Research Branch of the Oversea Service to 202 officers, and besides two continuing research fellowships, a further eight research studentships were awarded. Recruitment for moderately senior research posts continued to be difficult, but the Committee for Colonial Agricultural, Animal Health and Forestry Research reported more candidates for junior posts and awarded seven research studentships, bringing the total of research students to fourteen. The staff of the Colonial Section of the Road Research Laboratory reached sixteen during the year, but there are still nine vacancies. The staff of the geodetic and topographical surveys at the end of March 1958 was 437, and the overseas territories (excluding Malaya and Ghana) had 207 geologists, geophysicists and chemists on geological survey, with about twenty vacancies still existing, while meteorological work also was hampered by shortage of staff. It should be remembered, moreover, that the United Kingdom has already provided 317 experts under the Technical Co-operation Scheme of the Colombo Plan, an increase of 54 in 1957–58.

Apart from these items, "Colonial Research" gives no indication of the magnitude of the demand for man-power. Information on finance is equally sketchy. Expenditure under the Colonial Research Council during the year was £1,330,641 compared with £1,534,746 in 1956–57 and with £1,575,000 in the 1958–59 estimates. Colonial Development and Welfare Research Schemes made during the year brought the total allotted to such schemes under the Acts since 1940 to more than £18·5 million, of which £13·5 million has already been disbursed. Besides this, however, the United Kingdom has allocated since 1951 some £123·25 million for capital and technical assistance in the centres of south and south-east Asia under the Colombo Plan, of which £92·5 million had been disbursed by June 30, 1958

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* Colonial Research 1957–1958: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Science Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 347. (Cmnd. 591.) (London: H.M. Stationery Office, 1958.) 14s. 6d. net.

(£3·71 million of this was for the Technical Co-operation Scheme). About 35 per cent of the gross allocation from Colonial Development and Welfare Funds has been for agricultural, animal health and forestry schemes, 16 per cent for medical research, 10 per cent for fisheries research, 9 per cent for tsetse and trypanosomiasis research, 8 per cent for social science and economic research, 8 per cent for pesticides research, 5 per cent for research sponsored by the Colonial Products Council, 3 per cent for anti-locust research and 6 per cent for miscellaneous schemes. About 38 per cent has been for schemes to benefit the East African territories, 16 per cent for the West African group, 12 per cent for the West Indian Colonies, British Guiana and British Honduras, 8 per cent for the south-east Asian territories and Hong Kong and 5 per cent for the central African territories.

Apart from this indication of the broad distribution of the research effort, the report really shows little of its relation to Britain's own effort. There is, however, a significant comment in the report on fisheries research during 1957–58. The Colonial Fisheries Advisory Committee points out that, with the closure of the West African and the Singapore fishery research stations, both regional and both considerably endowed from Colonial Development and Welfare Funds, Colonial fishery research appears to have entered a new phase, and that for some time to come fundamental research will be regarded in some territories as beyond their means. More and more research institutes will be asked to concentrate on applied research.

The Colonial Fisheries Advisory Committee recognizes the situation, and it is watching with interest a joint research and development scheme in Sierra Leone; but the difficulty should be considered in the wider context of an observation to be found in the recent report of the Secretary-General to the ninth meeting of the Scientific Council for Africa South of the Sahara. Here, too, is recognized the increasing importance of local factors; but the importance of basic research in a developing continent is firmly stressed, and while activities in the inter-African field are intended to serve the interests of Africa, in doing so the fullest support must be given to European research workers, institutes and technical departments. For a long time to come Europe will provide most of the scientific and technical assistance needed in Africa.

Rightly the report directs attention to the way in which the Scientific Council for Africa South of the Sahara is qualified to assist this evolution. Its members have been trained in the highest European disciplines and are eminent scientists who have devoted much of their lives to research. At the same time, they are all Africans, by adoption if not by birth, for their work and experience, their life itself, have for many years been in the service of Africa. The Council's meetings are held in Africa and its discussions and recommendations during the past nine years have had the sole objective of enabling science to assist the development of Africa.

There are already close relations between the Scientific Council and those engaged in Colonial research under the auspices of the various advisory research bodies the reports of which are collected in "Colonial Research"—for example, those concerned with fisheries or with social science; and the most cursory reading of either "Colonial Research" or the report of the Scientific Council for Africa South of the Sahara will show how much of the work is interrelated. It is indeed in this context that Britain's own effort in Colonial research is most appropriately considered. Valuable as the detailed work done by British and other European staff still is, it must be taken over more and more by trained men and women in the territory served as educational programmes develop. Meanwhile, however, and for years to come, the Colonial and similar territories will depend on assistance from the United Kingdom and other Colombo Plan countries, and from the specialized agencies of the United Nations; and the shortage of trained man-power throughout the world makes it imperative that there should be no hindrances to the efficient use of whatever scientific and technical man-power can be placed at the service of the under-developed areas.

This accentuates the importance of establishing the political and economic conditions, as well as the scientific and administrative means, for effective co-operation, and lends force to the contention of the Scientific Council for Africa South of the Sahara that it is essential to maintain an advisory group of highly qualified scientists, representing the various disciplines with which the Commission for Technical Co-operation in Africa South of the Sahara and the responsible Governments are concerned. Only as co-operation is promoted effectively at the highest level can we expect to ensure both the conditions for efficient scientific and technical work, and the removal of the obstacles that could, if allowed to remain, engender frustration and waste of effort, if not lead to real misunderstanding. The establishment last year of the Foundation for Mutual Assistance in Africa, stimulated largely by the success of the technical assistance programme under the Colombo Plan, both indicates the value of such co-operation and should in due course encourage the territories to provide their own scientific and technical experts, though the immediate effect may well be, by facilitating exchange, to increase the amount of technical assistance.

It is difficult at the present time to over-stress the importance of these matters not simply to science and technology but also to the economic future of Britain and the Western world. Sir Harold Hartley, in his Fawley Lecture last November, touched on its bearing on Britain's economic future and the challenge to industry to assist in developing the less-industrialized countries. He stressed the importance of careful planning, and indicated the extent of the demand for help which could reach even one company, as well as the difficulties which economic conditions and a narrow nationalist outlook could cause. In another context, Sir Oliver Franks, in his chairman's address to Lloyds Bank, Ltd., referred to the dangers of allowing the gap between rich and poor countries to widen still further and to the policies that should be pursued to give effect to the undertaking to help the under-developed countries given at Montreal.

As Sir Oliver Franks points out, the under-developed countries cannot embark upon development programmes regardless of their own resources, and then demand that the industrial countries should underwrite them to any extent the under-developed countries wish. Nor is it reasonable to expect the under-developed countries, unguided, at this stage, to choose the right priorities in research, or to maintain a sound balance between fundamental and applied research, even if they could finance unaided the necessary programmes. It is at this stage, for years to come, that co-operation at the international level will be imperative, both in planning the programmes and in ensuring that the under-developed countries secure the maximum return from whatever resources in man-power, equipment and finance can be placed at their disposal through Colonial Development and Welfare Funds, the Colombo Plan, or the technical assistance programme of the United Nations.

There is still work to be done in creating the political conditions in which technical assistance is most effectively given, and much of the value of "Colonial Research 1957–58" lies in the conspectus it provides of the character and magnitude of Britain's effort in this field. It is important that this should be fully appreciated, particularly, in spite of Mr. Nixon's tribute to Britain's enlightened work, in view of the tendency to misrepresent colonialism. Some amplification of the picture as given in this report of the magnitude of Britain's effort in Colonial research in terms of man-power and finance, in comparison with the total research effort of the country and with the contribution of other countries to overseas research and development, might well be worth while including in future reports from the Colonial Research Council.

There is yet another aspect to consider. Under the Technical Co-operation Scheme of the Colombo Plan, the United Kingdom Government has provided the Pakistan and Ceylon Councils of Scientific and Industrial Research with scientific equipment for their laboratories at Karachi (£83,500) and Colombo (£80,000). Smaller sums have gone to the Plant Virus Research Laboratory, Manila, to the Soil Science Laboratory, Cambodia, and to the Agricultural Research Station, Kachim State, Burma. Such gifts all help to create the conditions in which effective scientific work is carried out, and the two thousand-odd trainees who have already been welcomed to the United Kingdom also help, on their return to their own countries, to promote the appropriate climate for research and development.

An even more important factor, however, may well be the conditions which already exist in the research institutions overseas, in the Colonial territories themselves and elsewhere. The standards maintained in such institutions must affect profoundly the quality of scientific and technical work in the territories they serve—for years to come and not simply while the work may continue to be carried out largely by scientists and technicians from Britain and other Western countries. The importance of the Colonial Research Council and of the various specialist advisory bodies, as well as of such bodies as the Scientific Council for Africa South of the Sahara, in this respect is not easily over-stressed and both from the reports on Colonial research and that of the Scientific Council for Africa, it appears that they are well aware of their responsibility. Nevertheless, "Colonial Research 1957–58" has a significance in this connexion which is not always appreciated. For many scientific workers engaged in research overseas, sometimes in comparative isolation, with slender opportunities for meeting their fellows, often in difficult or trying conditions, both technically and socially, the conspectus of scientific work displayed in the pages of this report represents one of the few opportunities which their work has of receiving attention. It is indeed a record of which British scientists have every right to be proud, and it might be worth while, both from Britain's point of view and that of recruitment to the Oversea Scientific Service, for closer consideration to be given to the possibility of giving more effective publicity to some at least of the many detailed achievements recorded in these three hundred pages.

QUANTUM MECHANICS IN ITS FOURTH DECADE

Quantum Mechanics

By Prof. H. A. Kramers. (Series in Physics.) Translated by D. ter Haar. Pp. xvi+496. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1957.) 45 guilders.

Quantum Mechanics

Non-Relativistic Theory. By L. D. Landau and E. M. Lifshitz. Translated from the Russian by J. B. Sykes and J. S. Bell. (Course of Theoretical Physics, Vol. 3.) Pp. xii+515. (London: Pergamon Press, 1958.) 80*s*. net.

Quantum Mechanics

By Dr. F. Mandl. Second edition. Pp. x+267. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 35*s*.; 7 dollars.

Angular Momentum in Quantum Mechanics

By A. R. Edmonds. (Investigations in Physics, Vol. 4.) Pp. viii+146. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1957.) 30*s*. net

Elementary Theory of Angular Momentum

By M. E. Rose. (Structure of Matter Series.) Pp. x+248. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 80*s*. net.

THIRTY-FOUR years ago, in 1925, quantum mechanics was born. The preceding twenty-five years had seen a gradual assembly of facts and a development of concepts which revealed startlingly the inadequacy of classical physics for describing atomic phenomena, but not until 1925 could it be claimed that the new situation was understood. The great discoveries, associated primarily with the names of Heisenberg and Schrödinger, gave us this understanding in what in retrospect appears as one brilliant flash of insight. In fact, the period just after 1925 was one of intense theoretical development, to which many individuals contributed, and it was five or so years before quantum mechanics in the shape now familiar was completely revealed. The men who took part in this development have since stood out as the great figures of modern theoretical physics, and they and their immediate pupils have dominated the developments of the subject until very recently. Some of these men, indeed, still remain in the forefront of research. However, to-day a new generation of theoretical physicists is taking over, for which the nineteen-twenties are a chapter of history, and it is for these and their pupils that new text-books and monographs must cater. The mere passage of time must inevitably change a student's attitude to a subject of study. If one has grown up trained to think entirely in the language of classical physics, the transition to quantal thinking cannot but be a painful process, and in learning quantum theory one's main preoccupation will inevitably be with the 'paradoxes' it introduces, with the reconciliation of the new concepts and the old. But, just as the learning of a new language in infancy is a process entirely different from that of learning it in adult life, so the modern student can and should be enabled to acquire a working knowledge of quantum mechanics without having to live through the labour pains of its creators. True, one must insist on the fact that the very formulation of quantum mechanics requires the prior establishment of classical physics, but the initial teaching of classical physics can and should be adapted from the start to the quantal generalization to come, and quantum theory itself can be introduced with much less of a retrospective attitude. Many of the questions of the detailed relationship to classical theory may be left to a more advanced stage of development, just as grammar forms a later stage in the teaching of a language to a child.

To relegate to a secondary position the deeper studies of the foundations of quantum theory may seem unsound to many, but the reviewer feels that if to-day one's pupils are to be guided to the forefront of research in the limited time available for their training (and this time is limited not primarily by the educational system but even more by the inescapable fact that the peak in creative ability is so often attained at a very early age) changes in the directions suggested are inevitable. If we older generation of teachers do not make this re-orientation, our successors will certainly do so.

Of the five books the reviewing of which has given rise to these thoughts, the first, a translation of H. A. Kramers's classic contributions to the "Hand- und Jahr-buch der chemischen Physik", appearing as a single book under the title "Quantum Mechanics", is an example of the traditional exposition of the subject. In its class this work is undoubtedly one of the greatest. Kramers's part in the developments of the 'twenties was a more important one than is perhaps realized nowadays, and he was also one of the greatest of teachers. (To him we owe among so many other things the concept of 'renormalization' which dominated developments ten years ago.) The translator and publishers deserve nothing but praise for making this masterpiece available to English-speaking readers. Nevertheless, it is not a text-book one would nowadays recommend for initial study. In particular the reviewer cannot agree that the first five chapters, which also have been issued separately under the title "Foundations of Quantum Theory", are "extremely suitable as a text-book for college purposes" as claimed in the publishers' announcement. These chapters, while providing an admirable, one may say inspired, analysis of the relation of classical and quantal theory, do not even take the development as far as the introduction of spin.

A very different spirit pervades the volume on "Quantum Mechanics (Non-Relativistic Theory)", which forms part of the nine-volume course of theoretical physics by Landau and Lifshitz. This is again a translation, and as in the case of the preceding work the reviewer is disposed to praise translators and publishers wholeheartedly, passing over the quite minor blemishes noted in both works. The Landau-Lifshitz series is undoubtedly a worthy modern successor to the classic German series of Planck and of Sommerfeld and it is modern in precisely the sense called for in the introductory remarks. "Quantum Mechanics" is not the ultimate volume of the series, but the third. Only (classical) "Mechanics" and "The Classical Theory of Fields" are designed to precede it and, with "Statistical Physics" to round off the 'basic' disciplines, such 'derived' subjects as hydrodynamics, elasticity and electrodynamics of continuous media follow in later volumes. This conception seems admirable, and to judge from the volume in hand the execution matches the conception. To the serious student of theoretical physics no better text-book could be recommended, even though the Russian original appeared in 1947 so that certain recent developments (for example, 'effective range' theory in scattering) are inevitably missing and the emphasis on molecular theory is perhaps rather greater than one would desire to-day.

The third book on general quantum mechanics is the only original English publication of the three, Mandl's "Quantum Mechanics". This is a much less ambitious work, much shorter, more elementary and, let us be grateful, lower in price. We are told that the book originated in a course of quantum theory given to 'experimentalists' at Harwell in 1952 and one can see from the book why the course was a success. The author does a splendid job in making the ideas and methods of quantum theory clear with the minimum of mathematical sophistication. However, it seems to the reviewer that the very fact that such courses are needed in such a specialized centre as Harwell casts a sad reflexion on our British methods of training physicists. While in the Soviet Union it seems to be natural to place quantum mechanics side by side with classical mechanics and electrodynamics as a basic discipline in physics, here we have brought up the majority of our own physicists as 'experimenters' whose training, almost by definition, debars them from acquiring the language and tools of this branch of their subject at an early stage, so that they must seek enlightenment late in their careers in specially designed courses and in books in which mathematical argument of the slightest complication must be laboriously spelled out. How much better if Mandl's fine little book need never have been written !

A sign of the dominant role of quantum mechanics in modern physics is the need for specialized monographs on particular topics in the field. The two volumes on "Angular Momentum in Quantum Mechanics" by Edmonds and "Elementary Theory of

Angular Momentum'' by Rose deal with one and the same such special topic. It is one that is included to some extent in any quantum mechanics text-book, but it has special importance in modern work, as these two monographs demonstrate, and is capable of being much expanded instructively and usefully. The difference between the two versions, which is considerable, seems to the reviewer to be just that in Edmonds's work the instructive character strikes one most, in Rose's the useful side. The latter author is himself responsible for a great many important applications of the methods here described, and in this monograph he has succeeded in bringing together in a unified form the mathematical theory underlying these methods as well as an extensive array of its applications, so that to future workers in the field the monograph will undoubtedly serve as a most useful manual. Edmonds in his shorter book lays relatively more emphasis on the formal and conceptual structure of the theory of angular momentum and his book is somewhat more of the nature of an expanded chapter of a text-book on general quantum mechanics. In fact, the Landau–Lifshitz volume contains an admirable chapter on this topic and the fortunate student who learns his quantum mechanics from that work will find himself fully equipped to master the further developments of this monograph. Edmonds's book will undoubtedly be appreciated by workers in the field not least because of the author's commendable policy of listing systematically and fully the great variety of symbols which, unfortunately, are in use to denote the various group theoretical coefficients in which the subject abounds.

N. Kemmer

PHYSICS FOR THE ELECTRICAL ENGINEER

Physical Basis for Electrical Engineering

By Prof. Thomas L. Martin, Jr. Pp. xii+410. (London: Macmillan and Co., Ltd., 1958.) 30*s.* net.

MOST engineers who have been out of college more than ten years, and many teachers of electrical engineering as well, will find food for thought in this book. Their first reaction may well be of dismay that it is now proposed to teach in a first course in electrical engineering (so the author suggests in his preface) a great deal of physics with which they themselves have only a slight acquaintance. After dismissing in the first two chapters the electromagnetic field *in vacuo* (from "Vectors and Scalars" via Poisson's and Laplace's equation to the Lorentz transformations and electromagnetic waves) the book goes on to describe modern ideas of atomic and nuclear structure, the structure of metals and of semiconductors, practical semiconductor devices, vacuum and gas tubes, dielectrics (including ferroelectrics) and the theory of magnetic materials.

Closer examination reveals the very real dilemma of the teacher of electrical engineering to-day. Wave-mechanics is carefully excluded from the book, and 'degeneracy' is not to be found in the index. Perhaps this is why the definition of Fermi-level in the text appears so inadequate that it has been supplemented by another definition in an appendix. But should one try to teach all these experimental phenomena, yet firmly refuse to dig in to the solid foundations? If there is not time to teach a student both physics and electrical engineering thoroughly, how valuable is a superficial account of the physics? Yet this is only the physical basis for to-day's electrical engineering—soon it will be yesterday's electrical engineering. (There is nothing here to help us understand the maser or the use of the concept of entropy in communication theory, for example.)

The extent of the work involved in writing a book which covers so wide a field as this book is not to be belittled, especially as it is fairly liberally supplied with references to original work to enable the reader to pursue his study of any particular point. But one does not need to be a specialist to pick holes in details. Among the dozen or so points noted in a quick reading, there is a suggestion on p. 185 that conduction in an intrinsic semiconductor commences "at some fairly definite temperature", and on p. 208 we are told there are semiconductor diodes and varistors and transistors, but on p. 210 "semiconductor diodes or varistors" appear to be one and the same. The treatment of space-charge-limited thermionic currents is not happy, and it seems clear that the author has neither read Langmuir's classic papers nor himself tried to measure accurately a 3/2-law characteristic.

To sum up, this book is a bold attempt to provide engineering students with knowledge of what the author considers to be the relevant branches of physics; but even the elementary student deserves a clear and accurate treatment of the topics, and there are some passages which are not up to this standard.

D. A. Bell

ANIMAL ECOLOGY

Animal Ecology

Aims and Methods. By A. Macfadyen. (Zoology Series.) Pp. xx+264+6 plates. (London: Sir Isaac Pitman and Sons, Ltd., 1957.) 40*s.* net.

THIS book is difficult to read owing to the use of multitudinous sub-headings which destroy the continuity of the chapters. Partly as a result of this, the treatment of individual subjects tends to be too slight: as soon as some topic begins to grow interesting, it stops short. It would have been better to have selected fewer subjects and dealt with them more thoroughly. Parts of the book are little more than a catalogue. On the other hand, the numerous references which this involves are certainly valuable, though their use is greatly impeded by the unfortunate device of splitting them up into fourteen separate lists at the ends of chapters instead of bringing them together to form a single corpus of literature.

The account of collecting methods (Chapter 6) is very brief and incomplete. Among other omissions, the mercury-vapour trap which has so much revolutionized our knowledge of the distribution and habitats of insects, especially the Lepidoptera, is not mentioned. The description of marking techniques is also too curtailed to be of use. It is condensed into a small paragraph on p. 89, and no mention is made of the exciting possibilities opened up by marking with radioactive materials (there is brief mention of their use in another connexion). The mathematical procedures to be used in marking – release – recapture work, which might certainly be expected in a book which sets out to include methods, are scarcely touched upon. One has the impression that the chapter on "Biocoenology" could advantageously be replaced by one on ecological barriers, which are scarcely mentioned.

Yet though too many minor topics have been chosen, some important major ones are omitted. The ecology of marine and estuarine animals and communities, and the methods of studying them, are insufficiently described, while the vast contributions of ecology to the study of evolution are relegated to three pages. The theory of Sewell Wright is said to fall outside the scope of the book, though it is not clear why. It is mentioned in two brief paragraphs, in which it is said that "the existence of small isolated populations provides unusual opportunities for the rapid evolution of new sub-species bearing characteristics which would not be tolerated in the more normal conditions of larger populations among which natural selection is in full operation". It should also be pointed out that such conditions provide unusual opportunities for solution by natural selection. No attempt is made to include the great subject of ecological genetics, though we are told (p. 13) that "the genetic structure of a population in the wild is constantly changing, for it is the result of an equilibrium between mutation rate of recessive factors and selective elimination of unsuccessful individuals". It is very surprising that such a statement, overlooking polygenic variation and polymorphism, could be made in a modern book.

The captions on Plate 2 are interchanged, as are the two lower captions on Plates 5 and 6. The price seems high for a book of moderate size containing eleven tables, nineteen text figures, six black-and-white, and no coloured, plates.

E. B. Ford

STUDY OF EARTHQUAKES

Elementary Seismology

By Charles F. Richter. Pp. viii+768. (San Francisco, Calif.: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1958.) 12 dollars.

At the present time, when geophysical methods and theories are permeating every branch of geology and geotectonics and effecting a gradual revolution in geological thinking, the appearance of a book which helps this process is an important event. Sound reasoning, likewise, in geophysics can only stem from a sound well-balanced basic knowledge of classical geology, physics and mathematics, ably synthesized as in the book under review.

This book is divided into three parts. Part 1, entitled "The Nature and Observation of Earthquakes", contains twenty-four chapters on 394 pages. The first fourteen chapters largely concern field observations of earthquake effects, the background for these chapters being geological and non-mathematical. Chapter 15 contains an elementary discussion of seismograph theory and practice, and there follow chapters on elastic waves, deep-focus earthquakes, and the reduction of instrumental observations. The final two chapters are on microseisms and on earthquake risk and protective measures to be taken in areas likely to be subjected to earthquakes.

Part 2 of the book is entitled "The Geography and Geology of Earthquakes" and contains nine chapters on 246 pages. The author of the book for many years has taken a very great interest in this work, and being thus exceptionally well qualified for the writing, cannot fail to be informative and stimulating. After an introductory chapter he sets off immediately into a discussion of arc and block tectonics, and follows this up with descriptions of the geotectonics and earthquake phenomena of California, New Zealand, Japan and Formosa. Most of these regions have been studied at first hand in the field by Dr. Richter, as also through the medium of instrumental data and literature. The part ends with chapters on the tectonic earthquakes of other regions; compressions and dilations; and on seismology in the U.S.S.R. Since the days of Prince B. Galitzin, Russia has been renowned for her students of seismology, and her sons to-day are worthy successors of this heritage (the late Dr. G. A. Gamburtsev; and Dr. E. T. Savarensky, Dr. D. P. Kirnos, Dr. V. I. Keylis-Borok, Dr. E. W. Karus and others).

Part 3 of the book, which contains seventeen appendixes on 100 pages, and is somewhat more advanced than Parts 1 and 2, being mostly composed of items useful in a seismological laboratory such as a list of seismological observatories, a table of angles of incidence of elastic waves in the Earth and related quantities for shallow-focus earthquakes; the refraction and reflexion of earthquake waves including the Zoeppritz equations; transit-time tables and magnitude charts. In addition, there are items frequently requested by the general public such as lists of large earthquakes, a chronology of historically important events and discoveries in seismology; and an appendix on earthquake-resistant construction.

As will be seen from the foregoing statements, the book is exceptionally well balanced, the proper weight having been given to field observations and geology. Within the limits set by the author it is comprehensive and even encyclopædic in its contents, being a masterpiece of selection and compression as only a practical seismologist and lively, experienced teacher could have accomplished. Since the book is so up-to-the-minute in its contents, however, one might have liked to see reference to recent experimental work on seismographs such as is being conducted at Stuttgart, Zürich and elsewhere—though perhaps the author includes this work in the list (on p. iv) of material abbreviated. However, there are very good lists of selected references by which anyone interested may pursue the studies so well begun.

The author, Prof. Charles F. Richter, is professor of seismology in the California Institute of Technology in Pasadena, California, where he has also worked for many years in the seismological laboratory with Prof. B. Gutenberg, Dr. H. Benioff and others. He is joint author with Dr. Gutenberg of the book entitled "The Seismicity of the Earth", and is an originator of the instrumental earthquake magnitude scale. For many years also Prof. Richter has been responsible for regular bulletins on local and distant earthquakes.

This book developed from a lecture course organized particularly for students of geology who do not intend to specialize in seismology or geophysics. Every geological library, and every geological student who can afford it, should get a copy of this book most opportunely published during the International Geophysical Year. It is lavishly illustrated and produced, and the printing, format and binding are all of the highest quality. The book is recommended not only to students of geology, but also to engineers and engineering students, applied mathematicians as a source book of data and ideas for problems, and to all others interested in seismology and the physics of the Earth.

Ernest Tillotson

Proceedings of the Rehovoth Conference on Nuclear Structure held at the Weizmann Institute of Science, Rehovoth

September 8–14, 1957, under the auspices of the International Union of Pure and Applied Physics (IUPAP). Edited by Dr. H. J. Lipkin. (Series in Physics.) Pp. xvi + 614. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1958.) 45 guilders.

THE Rehovoth conference of September 1957 will long be remembered by many who attended it, if only because it was their first opportunity to visit the young and fascinating State of Israel. Apart from that, the conference itself marks a certain stage of development of nuclear physics, a stage at which one feels that a qualitative and even semi-quantitative understanding of the structure of complex nuclei has been reached, and one beyond which must inevitably follow a period of consolidation. There is, in fact, some justification for the sentiment, sometimes expressed, that nothing much has happened in low-energy nuclear physics since the Rehovoth conference. There is, therefore, every justification for the appearance in print of the Proceedings of the conference provided in this handsome volume. The editor has been to great trouble to collate and edit the various communications, long and short, and has even included some carefully edited discussion. The sessions dealt with the shell model and the collective model and their foundations, group-theoretical methods in nuclear spectroscopy (including a beautiful introduction to the concept of seniority by Prof. Racah, who has contributed so much to the techniques of theoretical nuclear physics), electromagnetic properties of nuclei, beta-decay and parity violation, angular correlations in external fields, the instruments of nuclear spectroscopy, and the measurement of short life-times. A final section of the volume includes the *Daily Bulletin* of the Conference, which parodied and commented upon the actual proceedings with such delightful wit. In this permanent record of a memorable occasion the publishers have maintained their customary high standards of printing and presentation. B. H. FLOWERS

Physical and Azeotropic Data

Hydrocarbons and Sulphur Compounds boiling below 200° C. By G. Claxton. Pp. v + 146. (London: The National Benzole and Allied Products Association (N.B.A.), 1958.) 42*s*.

THE first part of this book gives the boiling points and densities of nearly 1,450 hydrocarbons and 190 organic sulphur compounds, together with the refractive indices of most of the substances listed and, in a few cases, melting points.

The second part describes the behaviour on boiling of about 1,000 binary, 90 ternary and three quaternary mixtures, azeotropic and otherwise. One component of every mixture is selected from twelve hydrocarbons and two sulphur compounds which are main constituents or impurities in coal tar benzoles. It is surprising, however, to find the benzene/ethanol azeotrope omitted from the list.

The first nineteen pages comprise a detailed explanation of the unusual system of nomenclature and classification used in the tables. These pages must be given careful study before the tables can be used, and the reader is not assisted by the incorrect printing of the four structural formulæ in Figs. 4 and 6, pp. 10–11. I would have preferred to see the standard nomenclature of the Chemical Society used in the book; the system is already widely known and leads generally to less cumbersome names than does that favoured by the author, and the reader would be spared the trouble of learning another system for which he will find no other use.

A few misprints occur, but the book should prove useful to all who use distillation for analytical or preparative separations and do not wish to use a more comprehensive work such as L. H. Horsley's "Azeotropic Data". B. A. ROSE

The True Book about Insects

By John Clegg. (True Book Series.) Pp. 144. (London: Frederick Muller, Ltd., 1957.) 7*s*. 6*d*. net.

THIS is not another book on identification, but one bringing together information—often to be found only in specialist or out-of-the-way works—on many of the fascinating aspects of insect life.

It describes briefly the general structure of insects and how they grow, with chapters on flight, respiration, the senses of sight, smell and hearing, on feeding, colouring and camouflage. There are interesting accounts of such subjects as plant galls, with life-histories of some of the insects concerned; life in water, with its special problems of breathing and movement; the nuisance to man caused by insects which feed on his crops or transmit diseases, and the remarkable ways of the social bees, wasps, ants and termites. A chapter is included on the use of insecticides in the struggle against pests, with mention of some of the ventures in biological control. Illustrations are good line drawings, and there is a short list of books for further reference.

The author has chosen examples for his text from well-known insects from overseas as well as Britain, and his simply written and enthusiastic account will make a good introduction for the young student of entomology. B. D. MORETON

Perkin Centenary—London

100 Years of Synthetic Dyestuffs. (Supplement No. 1 to *Tetrahedron*.) Pp. xii + 136 + 8 plates. (London and New York: Pergamon Press, 1958.) 42*s*. net.

THIS book, to which Sir Robert Robinson contributes a foreword, provides a permanent record of the proceedings of the Perkin centenary celebrations. Besides the four Perkin centenary lectures, by Prof. John Read, Mr. C. Paine, Mr. J. G. Evans, and Sir Alexander Todd, it includes the speeches made at the Perkin banquet, details of the committees which planned and organized the celebrations, and the final financial report of the Perkin Centenary Fund, with a list of contributors to it. There are some interesting plates of Perkin himself, the Royal College of Chemistry, Hofmann and his students and the Greenford Green works. Prof. J. Read has put us further in his debt by appending to his own vivid survey of the life and work of Perkin references to some other papers on Perkin published at the time of the centenary or afterwards. The completeness thus given to the volume is a further reason for regretting that, while its production is worthy of such a notable event, the volume has not been produced in a style which would place it within the reach of a much wider range of chemists and general readers to whom its present price may be prohibitive.

R. BRIGHTMAN

THE THEORY OF NATURAL SELECTION TO-DAY*

By PROF. J. B. S. HALDANE, F.R.S.
Indian Statistical Institute, Calcutta

WE constantly hear that Linnæus is out-of-date, that his ideas are a danger to clear thinking, and so on. Why, then, do we not relegate them to a place in the history of science, like those of his contemporary Scheele on phlogiston ? The answer is quite clear. Whatever we may think of Linnæus's theories, we continue to use his methods. In science, methods are much more important than theories, because a theory is an attempt to describe reality in terms of symbols made by the human vocal apparatus or on paper. If we think that the properties even of an electron are inexhaustible, theories can never be adequate. But a method, that is to say, a way of dealing with reality, may be adequate for the purpose for which it was designed, even if it is based on a false theory. The transition from a fluid to a particle theory of electric conduction in metals, and the partial return to a degenerate gas theory, had no effect on the design of galvanometers.

Linnæus invented the method of describing every animal or plant in terms of two, and only two, words. A group sharing the same two names is called a species. A group sharing the first only is called a genus. Genera are grouped together in higher categories, such as families, orders, classes and, more recently, phyla.

It is worth comparing this with some other methods of classification. To identify a particular star we give its right ascension and declination. In order to group stars which are judged to be similar, we use another two-dimensional classification. One co-ordinate is the surface temperature or a character highly correlated with it, such as the spectral type or colour. The other is the absolute luminosity. We then find that stars which agree in both these respects usually agree in others, for example, their period if they pulsate, their probable age, and so on. Linnæus tried such a two-dimensional classification of flowering plants, and it was one of his least-valuable contributions to biology.

The Linnæan system of classification is much more valuable in the tropics than in temperate or arctic climes, for the simple reason that there are many more different species of animals and plants. Linnæus's flora of Lapland was probably fairly complete. I am sure that nobody supposes that we have yet a complete list even of the flowering plants, let alone the ferns, mosses and liverworts, of Malaya. So it is no reproach to tropical biologists that they are still at the Linnæan stage when those of temperate climates have gone beyond Linnæus. One might as well reproach students of proteins because they cannot yet describe the structure of proteins with the accuracy possible for sodium chloride. It is therefore entirely fitting that we should be commemorating Linnæus on the equator.

If Linnæus's method of assigning every living organism to a species is so useful, why do we attack his species concept ? The species concept, like the concept of a molecule, is not always true ; but even where not true, both can be useful. Sodium chloride does not exist as molecules either in crystals or in solution. But it is convenient to use the same terminology to describe sodium chloride and carbon tetrachloride, though the latter is a true molecule. Similarly, we can describe a silicate the anion of which is a lattice of indefinite extent in terms appropriate to a small molecule. By the end of this century I expect that our chemical vocabulary will be brought up to date. I do not think the Linnæan terminology will be abandoned for several centuries.

The Linnæan species concept often breaks down when we extend our studies over a large enough space. Classical cases are the circum-Tibetan distribution of *Parus* and the circumpolar distribution of *Larus*. Here differences, which are at best subspecific, add up to a specific difference. The principal postulate of evolutionary theory is that all, or almost all, specific differences disappear if we trace the ancestry of two species far enough back. Thus, the horse and ass are believed to be descended from one ancestral species in the Pliocene, the horse and any bird from a common ancestral species in the Carboniferous. Finally, recent work on the transfer of substances (perhaps always deoxyribonucleic acid) responsible for hereditary differences, between bacteria not only of the same but also of different species, suggests that the species concept is only roughly applicable to bacteria.

But most biologists, and particularly experimental biologists, are dealing with organisms living in the present and obtained in a particular locality. The determination of their Linnæan species is a prerequisite to description of other observations. It may be said that the Linnæan system is merely a convenience of human communication. This is perhaps true, but it raises the question whether any scientific theory, or for that matter any philosophical theory, is anything more than such a convenience.

It is not a trivial fact that Linnæus worked on the periphery of the area where science was studied in his time. This meant that rather few of the plants and animals of his native country had been described either by the scientists of the ancient Mediterranean culture such as Aristotle and Theophrastus, or by such men as Aldrovandus and Gessner. Two centuries earlier, when Britain was similarly peripheral, Turner had realized that the plants and animals of his country required special study and special names.

It is not trivial that Darwin and Wallace were stimulated to formulate the theory of evolution as they did by observing the plants and animals of countries very distant from their own. A four-year voyage around the world gave Darwin enough facts inexplicable without a theory of evolution to last him a life-time, but in his case the theory germinated slowly. Wallace had spent much longer in the tropics, and produced a theory equivalent to Darwin's in a shorter time. It is not impossible that some resident in a scientifically peripheral area such as Singapore or Calcutta may to-day be making observations which will form the basis of an advance in biology comparable to those made by Linnæus two centuries ago, and by Darwin and Wallace a hundred years since. I shall later suggest reason to hope that Calcutta may be the locus of such a discovery.

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* Substance of the presidential address delivered at the Centenary and Bicentenary Congress, University of Malaya, Singapore, on December 2, 1958. (See also p. 723.)

Darwin and Wallace not only championed the notion of evolution, but also produced a coherent theory as to how it had occurred. To-day almost all biologists believe in evolution, that is to say, they believe that the plants and animals alive to-day, including men, are descended from ancestors very unlike themselves, and that many very different living forms are descended from one ancestral species. However, by no means all living biologists believe that the main agency of evolution has been natural selection. Indeed, Wallace in his old age concluded that a decisive step in the evolution of man could not be so explained.

Darwin thought that evolution occurred by imperceptibly small steps. To-day we know that some of the steps have been fairly abrupt; and this is the main modification to which the account of evolution given a century ago must be subjected. These steps are of three main kinds. Mendel showed that on crossing races of peas certain characters showed no blending. Even when a character disappeared in the first generation it might reappear in a fraction of the next. We know that some evolutionary steps are due to the selection of characters inherited according to Mendel's law. About seventy species of British Lepidoptera have evolved black varieties since the industrial revolution, and some have almost completely replaced the original light form in the smokiest areas. In the best-studied case, *Biston betularia*, the dark form differs from the light by a single dominant gene. I shall later describe why the population evolved as it did. At present I merely wish to point out that the evolutionary process was not gradual, in the sense that the population did not pass through a phase of intermediate colour.

Secondly, the chromosomes, on which the genes responsible for Mendelian inheritance are carried, change abruptly. The number in a species is usually constant, and must be an integer, usually an even one. Not only does the number change, but also when a new species evolves, parts of two different chromosomes can be exchanged, so that in the hybrid the normal process of gamete production by meiosis is disturbed. This is not the only cause of hybrid sterility, perhaps not the main one, but it is one cause of this important biological fact.

Thirdly, and most important, we now know that a new species can arise in one step by the formation of a sterile or nearly sterile hybrid followed by a doubling of the chromosomes which renders it fertile but still vigorous. Such hybrids, which are called allopolyploids, breed very nearly true. While Winge and others must take much credit for this discovery, the most decisive steps were probably taken by the Japanese botanist Kihara, who recently crowned his life's work by discovering growing as a weed in wheat fields in Afghanistan the grass which, by crossing with a wheat like the macaroni wheats of to-day, gave rise to the bread wheats in or near Afghanistan about 6,000 years ago. It is probable that Kihara has made the most important amendment to Darwin and Wallace's account of evolution as a historical fact.

Finally, Garstang, Bolk, de Beer, and others have pointed out an evolutionary process at which Darwin and his immediate successors had not guessed. Many animals pass through a larval stage, and this may be highly specialized for its own kind of life. You have only to think of such familiar larvæ as a caterpillar and a tadpole. If the timing of development is shifted so that reproduction occurs when some or most of the non-reproductive organs are still in the larval stage, this may lead to the evolution of a wholly new adult type. Such are, for example, the Larvacea, or swimming tunicates, which resemble the larvæ of the sessile forms, but never attach themselves to rocks. It is probable that the Copepod Crustacea, a very successful order, are essentially larvæ of prawns or crabs which never grow up. A similar process has played a great part in human evolution. The development of our nearest relatives is very slow. A chimpanzee is not mature until about eight years. A human being is not mature until about sixteen, and never develops many of the characters of adult apes, let alone adults of other mammalian groups. In particular, we have kept the embryonic character of cranial flexure, so that our eyes are directed forwards and not upwards or even backwards. A change in the timing of sexual maturity may occur quite suddenly, as it does in the axolotl, and have very great evolutionary effects.

Nevertheless, palæontological research has, on the whole, fully confirmed Darwin and Wallace. Among the more spectacular 'missing links' which must have lived if their account of evolution is substantially correct, and are no longer missing, though they were so in Darwin's time, are amphibians with four legs but a fish-like tail with bone-supported fins, birds with long tails, teeth, and many other primitive features, and later short-tailed but still toothed birds. Our picture of vertebrate evolution is now so complete that one can make a list of dozens of discoveries, any one of which would go far to disprove the theory of evolution. For example, if the skeleton of a man or a horse were discovered in the Cretaceous, or that of a reptile or a bird in the Devonian, I, for one, would regard most of my life's work as having been as futile as that of an astrologer. Every year in which such discoveries are not made strengthens the evidence for the theory of evolution, and makes it less possible for biologists to accept any other theory.

Although both Darwin and Wallace made major contributions to the study of variation (and Darwin did some very important genetical work), we now know so much more than they did on these matters that their account of how evolution occurs must be restated. In my opinion, most of what they wrote is true; but the fact that they reached the truth on the meagre evidence before them is a proof of their genius.

Let me try to state the theory of natural selection as I hold it in language which they would have understood. "All species vary. But not all variation is inherited. Natural selection discourages most variations from the structures and functions normal in a species. It encourages a few variations; and if these are inherited, evolution will take place."

The main objection to this formulation is to the word 'inherit', which is applied to property and to characters. For example, I have inherited my father's watch, his baldness, and a growth of bristles on the nose. We could not both possess the watch simultaneously, but we were simultaneously bald. It may be incorrect to speak of possessing baldness, but we certainly possessed the nasal bristles simultaneously. A character is not an object like a watch, and it is misleading to use the same word about it.

The physical basis of heredity is now fairly well understood. Certain patterns in cells are copied with great fidelity when a cell divides. The most important are the molecular patterns which we call genes, and which determine what kinds of proteins will be built in the new cells, and thus may have a great effect on the structure and function of descendant cells and organisms. However, a character, such as tallness, hairiness, or capacity for distinguishing between green and grey, can only be said to be inherited if it depends in a fairly simple way, either on genes in the nucleus, or on the rarer copiable molecular patterns outside the nucleus. A change in one of these copied patterns, whether it is due to copying error or alteration between copyings, is called mutation.

Heredity can be defined statistically as a positive correlation between characters in a group of ancestors and their descendants, which is not due to a positive correlation between the environments of ancestors and descendants. My skin colour is hereditary in the biological sense, my linguistic habits are not. My mother taught me to speak English; but if I had been handed over to a Malay foster-mother as an infant, I could just as easily have learned to speak Malay.

An example of a biological and genetically determined character which is not inherited is the complete sterility of some so-called double-flowered plants such as the double *Matthiola incana*. Other characters, such as size within a pure line, are not inherited, because they are not genetically determined any more than are human languages.

Natural selection may be defined as a statistical difference between the parents of the next generation and the population from which they are drawn, each parent being counted once for each of its progeny. Darwin and Wallace thought mainly in terms of selection by survival, but fully recognized selection by fertility, parental care, and other means. We now see that selection, whether natural or artificial, is not always effective. For example, roan cattle (which, by the way, are common in England and very rare in India, though they exist, but may be unknown in Singapore) do not breed true, and selection in favour of roan may increase the frequency of roan to about 50 per cent, but cannot raise it above this level.

But as soon as biologists began to study natural selection they found something much more surprising. Natural selection is generally centripetal, that is to say, it favours individuals near the norm of the population in question, at the expense of those which deviate from it. In other words, the parents of the next generation are usually less variable than the generation of which they form a part. This is difficult to prove formally, because one cannot often determine parenthood in animals or plants under natural conditions, but it has been abundantly proved for many episodes of selection by killing. Perhaps the first case was Bumpus's observation in the late nineteenth century that of a number of sparrows picked up immobile with cold after a blizzard, those which did not recover were more variable in several measurable characters, such as wing-span, than those which did.

In the human species, centripetal selection occurs at all stages. For example, babies which are lighter or heavier than the average have a higher death-rate than the average. So have adults with very high or low weight or systolic pressure. When it comes to intelligence, the very stupid, who are classed as mental defectives, have a much higher death-rate than the average, and the survivors are less fertile than others, as they are largely confined in special institutions or in prisons. The very intelligent are probably longer-lived than the average, but are less fertile.

Centripetal selection acts partly by eliminating mutant genes, and partly by eliminating homozygotes, that is to say, organisms which have a like pair of genes, instead of an unlike pair, in a particular region of a chromosome. Thus, the first observations certainly confirmed Darwin and Wallace that natural selection occurs, but showed, contrary to their belief, that its main effect was to prevent species from changing. Only much later was natural selection with an evolutionary effect discovered.

The reason for this is clear enough. Evolution is a very slow process, how slow only Darwin guessed. He estimated the age of the Wealden, or upper Jurassic, at about 300 million years. His contemporaries, if they believed the theologians, put it at 6,000 years; if they believed the physicists, at about a million. The correct figure is about 130 million. In a fairly steadily evolving line such as the ancestors of horses, the average rate of change of a character, such as length of tooth, is about 4 per cent per million years. In 1924 I calculated the intensity of selection needed to make such changes. An advantage of one-thousandth for one type over another would be much more than enough; and this could only be detected on a sample of several millions, whereas a 10 per cent advantage could be detected on a sample of a few hundred.

In fact, natural selection with evolutionary consequences has only been observed where men have created drastically new conditions which impose a heavy selection pressure. The most striking is the use of insecticides such as DDT. This causes intense selection in favour of resistance to it, and relatively resistant races of mosquitoes arise in a few years. The best-studied case is that of the moth *Biston betularia*. In the smoke-polluted parts of Britain the original light form is conspicuous when resting on tree trunks, as these moths do during the day. In the unpolluted areas the dark form is equally conspicuous. Kettlewell found that birds ate the form which is conspicuous to human eyes at such a rate that if equal numbers of the two forms are released at dawn, the ratio of inconspicuous to conspicuous moths caught in flight the next night is 2 : 1. Thirty years earlier I had calculated, from the rate at which the numbers of the black form had increased, that the fitness of the light form in smoke-polluted areas was about 70 per cent of that of the black. This may well be true on an average, for Kettlewell chose a highly blackened wood near Birmingham for his experiment.

I have no doubt that natural selection of much less intensity, but yet with an intensity far greater than that which has been usual in the past, is going on in many species. But it would be difficult for a single worker to collect the data.

Can natural selection explain evolution? If Darwin thought that it could, this was perhaps because he thought that members of a species varied in all possible directions, and natural selection could favour any kind of variation. This is probably not so. Only certain kinds of heritable variations seem to be possible in any particular species. The course of evolution is not (except perhaps in very rare cases) determined by the frequency with which a particular type of mutation occurs; and the vast majority of mutations are rejected as useless, the process of rejection being called centripetal selection. No important event has only one cause. Houses would not be burned down if they were all made of ferroconcrete, or if the air only contained 17 per cent of oxygen. If there were no mutation, natural selection would be ineffective; if there were no natural selection, every species would become a collection of freaks. Only in this rather restricted sense can it be claimed that natural selection explains evolution.

However, it does not follow that the claim is true. In contradistinction to Wallace, I think it probably is true. Let us take such an organ as the eye of a man or a bird. It has been argued that it could not have evolved by natural selection, because it would seem that any improvement, in the later stages at least, would require simultaneous changes in several of its measurable magnitudes. I think a careful study of the eyes of living molluscs greatly weakens this argument, as we can find among them a dozen or so stages from a mere light-sensitive spot to an eye with a lens and retina much like our own. Wright has shown how, in small animal or plant communities, several changes, each slightly harmful, but beneficial in combination, may occur together.

Wallace regarded the origin of certain characters which he considered to be specifically human as inexplicable by natural selection. Many such characters, including a disposition to monogamy and a respect for property, both of which human moralists might envy, have since been found in animals. I have also shown, or at least suggested, how a mode of behaviour originated by the initiative of a single individual, and then converted, by imitation, into a tradition, may become instinctive as the result of natural selection. Until it has been shown that my arguments are worthless, it may be rash to say that natural selection cannot account for such changes. It is equally rash to assert dogmatically that it can.

If this celebration were merely concerned with eulogies of three great men, it would be worse than useless. If it helps us to imitate them, it is of the greatest value. Linnæus, Darwin and Wallace had this in common, that they did not use complicated apparatus. Any student to-day would turn up his nose at Darwin's microscope. Now we in India find it difficult to get apparatus. This discourages us from some lines of biological research. We cannot get electron microscopes, highly purified amino-acids, and so forth. But we can get land and labour to grow plants or keep animals, we can collect them on a large scale, and we can at least travel all over India. I want to tell you what I am trying to do in these circumstances.

I have already acted as a catalyst in getting one of the world's leading palæontologists (Dr. Pamela L. Robinson, University College, London) over here; and, with Indian colleagues, she has, in about ten weeks work, obtained reptilian and fish fossils, some of which are new to science, while others date some mesozoic formations with considerable precision (*Nature*, 182, 1722; 1958). Similarly, I hope shortly to catalyse the visit of one of the world's leading systematists to attack a group of animals the Indian representatives of which are practically unknown. My own junior colleagues are at last continuing the study of variation where Karl Pearson and Bateson left it fifty years ago.

Perhaps I may begin with a discovery made by a colleague, Mr. K. Dronamraju. Darwin directed attention to heterostylism in *Primula* and other genera. In many species there are two types of plant, in one of which the flowers have long styles, in the other short. The position of the anthers also differs. The phenomenon is called heterostylism. Darwin found that crosses between flowers of the different types gave far more seed than the so-called illegitimate unions between plants of the same morphological type. As no work of this kind has been done in the tropics, I asked Mr. Dronamraju to look for a suitable plant near the Indian Statistical Institute; for the assessments of fertility and of the viabilities of seeds in such cases raise some interesting statistical problems. Mr. Dronamraju discovered something much more important. He found both long-styled and short-styled flowers growing together on each of five trees of *Bauhinia acuminata*. So far, his results are merely statistical. In a year or two I hope that he will have physiological results also. This observation would most certainly have excited Darwin, who did not attempt to hide his emotions, so that his books are full of such adjectives as 'wonderful' and 'beautiful'. It is at least possible that heterostylism started as a variation between flowers on the same plant, and that, later, genes which controlled it were evolved.

Another colleague, Mr. S. K. Roy, is also almost slavishly imitating Darwin's interests. He has measured the amount of earth brought up by earthworms in Bengal and Bihar, and his measurements are the first to be made in Asia. A proper understanding of Asian soils demands that they be repeated in a thousand different places. I hope that some will be in Singapore or Malaya. He is now working, among other things, on variation in the like parts of the same plant. In a number of individuals of three different species he has reached the startling conclusions that while the mean number of petals per flower does not alter much during a season, the variance usually increases, and may be doubled. If the size of pots made by a potter became more variable at the end of a day, we should say that he was getting tired. I do not know what we are to say about a plant. To reach this conclusion, Mr. Roy has examined about 200,000 flowers. It is an interesting coincidence that Dr. A. K. Sharma, with his wife and other colleagues in the University of Calcutta, are working on differences in chromosome number in different organs of the same plant.

The point which I want to make is this. Apart from genetics, which can scarcely be understood without some special knowledge, no work is going on under my supervision which Darwin or Wallace would not have readily understood, and which is not, in fact, a continuation of a line of work started by one of them. Nevertheless, most of it is original in the sense that it is not an attempt to extend to tropical animals and plants principles which have already been established as holding in Europe, North America or Japan. It was Wallace, above all, who saw that certain biological problems are forced on one by a study of tropical life, which are by no means so obvious in temperate climates. The converse is, of course, true. Many ecological questions are fairly simple in the arctic regions, where a biotic community may consist of only twenty or thirty species; more difficult in the temperate zone, where a hundred or more species must be considered; and extremely complicated in a tropical rain forest, where it might be necessary to consider thousands of species, many as yet undescribed.

RIVER FLOW IN GREAT BRITAIN, 1955–56

By PROF. DAVID L. LINTON
Department of Geography, University of Birmingham

HYDROMETRIC statistics derived from regular measurements made at gauging stations on British rivers were first published by the Ministry of Health in 1938 and then lapsed during the War. Two volumes, published in 1952 and 1955, each covering eight years, brought the record (in a condensed form) up to 1953. "The Surface Water Year Book of Great Britain, 1955–56" (H.M.S.O. For the Ministry of Housing and Local Government, 1958. 15*s*. net) is the third in the new series. [It has been followed after a short interval by the fourth of the series, dealing with the period 1956–57.] The volume for 1955–56 contains results derived from 128 gauging stations maintained for a variety of purposes by river boards, water-supply undertakings, county councils, hydro-electric authorities, and others, and gathered together by the Surface Water Survey. For a minority of stations the records are incomplete or defective in some respect; but for the great majority we are given for each month of the hydrological year (October 1955–September 1956) the observed mean rate of discharge in cusecs (cu. ft./sec.): the gross mean (or natural) rate of discharge (in which allowance is made for additions or abstractions for reservoir, canal or hydro-electric purposes); the highest and lowest mean daily rates of discharge in cusecs, and the highest observed rate of discharge in cusecs however brief its duration, together with the date of its occurrence. From these data two further quantities are derived and tabulated for each month, namely, the gross mean discharge per square mile of catchment area, and the 'run-off', while the rainfall received in each of the twelve months and the corresponding mean monthly rainfalls are added for comparison. Finally, appropriate yearly rates or totals are quoted and some data are supplied concerning the location and character of the gauging station, the extent and hydrological character of the area draining to it, and the length and nature of the record.

Examination of the tabulated figures does not need to be very prolonged to reveal that the Tay is the most copious river of Great Britain. Its mean rate of discharge of 4,146 cusecs for the water year 1955–56 (and of about 4,000 cusecs over a ten-year period) at Caputh, where it emerges from the Grampian Highlands after draining 1,238 square miles, is not even approached by any rival. The Ness outflow of Loch Ness yielded 2,574 cusecs, and the Spey at Aberlour 2,188 cusecs from 692 and 1,020 square miles, respectively, and these figures differ little from longer-period averages. The figures for the 1955–56 mean flows of the Thames at Teddington (3,810 square miles), the Severn at Bewdley (1,650 square miles) and the Wye at Cadora (1,560 square miles) were 1,811, 1,557 and 1,806 cusecs, but longer-period averages of 2,373, 2,285 and 2,484 cusecs, respectively, are quoted. Maximum flows for a single day follow a similar order: in 1955–56 they were for the Tay 31,500, Ness 12,000, Spey 20,000, Thames 10,700, Severn 13,200 and Wye 13,900. Over longer periods higher rates of flow have been recorded or estimated, namely, Tay 42,000; Ness 20,900; Spey 27,000; Thames 27,900; Severn 23,000 and Wye 32,000. Some other rivers have had high flood flows, and the figures of 40,000 cusecs for the Aberdeenshire Dee at Woodend from 220 square miles; of 16,800 cusecs for the Welsh Dee at Erbistock from 401 square miles; and 21,000 cusecs for the Irwell in Manchester from only 226 square miles, are notable.

The Tay is the only British river for which the mean daily flow never fell to 1,000 cusecs during 1955–56. Minimum daily flows for the other rivers mentioned above were Ness 550, Spey 585, Thames 243, Severn 320 and Wye 312. Minimum flows for purely lowland rivers may fall to such very low values as 23 cusecs for the Great Ouse at Bedford or 21 cusecs for the Nene near Peterborough, because of high summer evaporation. For such rivers the ratio of the largest and smallest mean daily flows may be 80 or 90 to 1. For the Ness, on the other hand, it is less than 22, while for the Tay, Thames, Severn and Wye the ratios are 30, 44, 41 and 45 to 1. Very high values of this ratio are found for many small streams, of which 180 for the Monnow, 237 for the Medlom and 900 for the Essex Blackwater may be cited as examples.

Since rates of flow are tabulated for each month of the water year, seasonal variations can to a certain extent be studied. Highest values are most generally in December, January and February, when evaporation and transpiration are at a minimum. Other high values may reflect either seasonal rainfall maxima in October and August normal to the areas concerned, or high discharges connected with particular rainy spells. Comparison of the flow records with the periods of heaviest rainfall tabulated in the pages of "British Rainfall" would doubtless be revealing. Since seasonal flow can be so dominated by spells of abnormally heavy rain, many years records will be required before normals of monthly flow can be established.

While the points mentioned above are evidently of interest, they do not lend themselves to any but the crudest comparisons of one stream with another. For more refined or more far-reaching analysis, cartographic treatment is necessary, and it is remarkable that nothing of the kind is attempted in the present volume. Four quantities which will here be called the 'run-off', the 'run-off deficit', the 'specific discharge' and the 'discharge ratio', are appropriate for such treatment. Of these, the first is tabulated for 107 gauging stations, and the third (though under another name) for 109; the other two have not apparently received any consideration by the Surface Water Survey; but they can readily be derived for the 90 catchment areas for which the total rainfall for the hydrological year 1955–56 has been supplied. The cartographic representation of these four quantities is shown in Figs. 1, 2, 3 and 4.

In the catchment basin of any stream above a selected gauging point, the rainfall received in a water year will, of course, vary from point to point, possibly quite widely; but if enough records are available an isohyetal map may be drawn and the mean rainfall (P) may be determined and expressed in inches. A sheet of water of that depth and covering

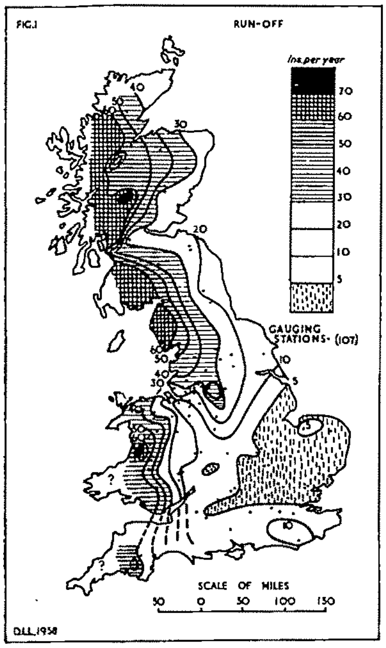

FIG.1 RUN-OFF

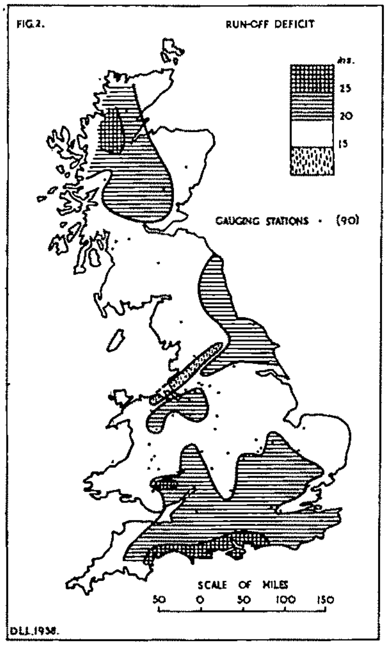

FIG.2. RUN-OFF DEFICIT

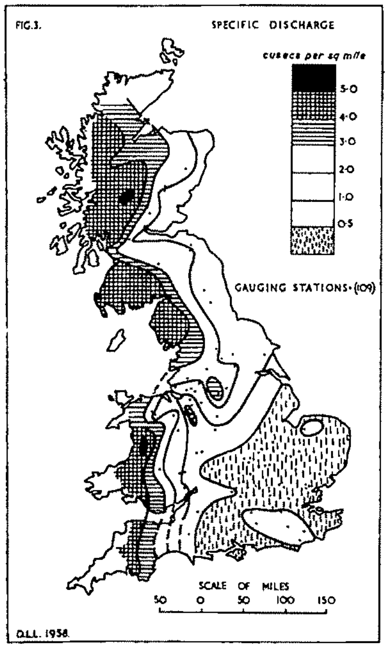

FIG.3. SPECIFIC DISCHARGE

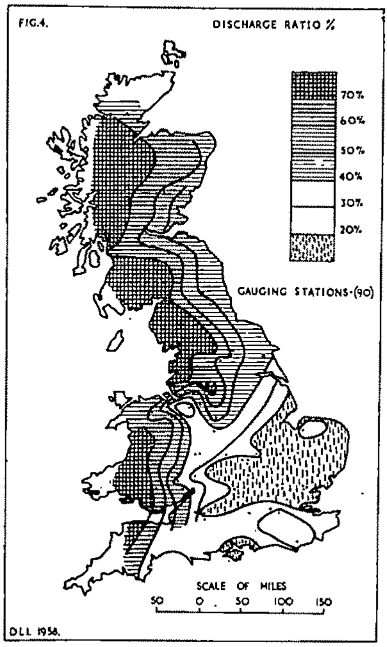

FIG.4. DISCHARGE RATIO %

the area of the drainage basin would equal in volume the total rainfall received. Of this total, a quantity (Q cu. ft.) is actually delivered to the gauging station in the course of the year. This quantity deserves a name, and, it is here suggested, may best be called the annual 'delivery' of the basin. If the delivery (Q cu. ft.) be divided by the area (A sq. ft.) of the basin, the quotient is a quantity exactly comparable to the mean rainfall of the basin, and like it may be expressed in inches. This is tabulated for 107 streams as the 'run-off' (R), and its variation over a large part of Great Britain is shown in Fig. 1. It is thought that the features shown by this map for 1955–56 would strongly resemble those for any other water year, and that they are, therefore, worth a little discussion. The wide range of variation (the ratio maximum/minimum is 73/1·7 or 43) will at once be noted as greatly exceeding the range of mean rainfall (200/19 = 10·5) in the same area. Moreover, it will be noted that extreme high and low values prevail over larger areas than the extremes of rainfall. Almost the whole of the English Plain, which receives rainfalls of 20–35 in., has run-off values less than 10 in. a year, and over most of East Anglia, the Fens and the Thames Valley the values are less than 5. At the other extreme, large areas in western Scotland and Cumbria, and small areas in Wales and Dartmoor, yield an annual run-off in excess of 60 in., though no data are available concerning the run-off in western coastal districts. Between the extremes, values of R fall off sharply from west to east and the isopleths probably migrate eastward in wet years and westward in dry years, leading to marked year-to-year fluctuations in areas like Peebles, the West Riding, or Herefordshire. An interesting feature is the extension of quite low run-off values as far as Chester in the rain-shadow of the Welsh uplands, and the rapid increase northward through Lancashire to Morecambe Bay. The local increases shown in Norfolk, the Sussex Weald and the High Peak are probably real features, though they may well be less marked in other years. On the other hand, the local minimum recorded for a small stream (Allt Bhlaraidh) west of Loch Ness appears out of accord with other available records in the region (Beauly, Ness and Lochy) and it is possible that it may be untrustworthy.

It is evident that the run-off (R) may be expected to be less than precipitation (P) in the same area by an amount representing the water lost by evaporation from the ground or transpiration from natural vegetation or crops. The amount of this difference ($P - R$) is thus a measure of evapo-transpiration and may be termed the 'run-off deficit' (D). Values of D in inches are expressed cartographically in Fig. 2. Here the range of variation in the recorded values is quite small (28·2/12·3 = 2·3 only) and, in fact, most of the values depart only by small amounts from 20 in. a year. There is a detectable tendency for higher values to occur in the south, where evaporation can be expected to be greatest, but high values are also recorded in the Scottish Highlands, presumably reflecting the great amount of exposed water available for evaporation. Elsewhere the variations appear a little capricious, and doubtless reflect in some way the influence of particular weather spells in certain areas. This map will probably show much variation from year to year in the location of the isopleths; but the broad fact that it reveals—namely, that evapo-transpiration levies a sort of overhead charge of roughly 20 in. a year from each and all the river basins of Britain—is doubtless a long-term reality. Figs. 1 and 2 are, in fact, complementary. Together they account for the whole of the rainfall received in the water year ($R + D = P$), but they show that the geographical variation of the fractions disposed of by run-off and by evapo-transpiration is radically different. It is to be doubted whether there has previously been any general appreciation of this difference by water engineers or others.

The third map (Fig. 3) shows variations tabulated in the report as "gross mean discharge per square mile", that is, the mean quantity of water in cubic feet contributed every second from every square mile of the catchment basin concerned to its total delivery. Since it represents the flow contributed per unit area it would seem appropriate that this quantity should be called the 'specific discharge' (S). Physically it has the same dimensions as the run-off, the two quantities being numerically related thus:

$$\frac{R}{12} = S \times \frac{365 \times 24 \times 60 \times 60}{5280 \times 5280} \text{ or } \frac{R}{S} = 13{\cdot}57$$

Ideally, therefore, the 2-in. isopleth in Fig. 3 should correspond to an isopleth of 27·15 in. of run-off in Fig. 1; but because the nearest isopleths in Fig. 1 are drawn at 20 and 30 in. some divergences, of course, actually appear. The map of specific discharge yields no distributional information not implicit in Fig. 1 but gives numerical expression to a very different way of regarding the same data. Whereas Fig. 1 obviously invites comparison with the rainfall map, Fig. 3 allows one to say simply by inspection that the mean flow in 1955–56 from 120 square miles of catchment in Caermarthenshire probably exceeded 480 cusecs, while the flow from an equivalent area of east Suffolk was probably less than 60 cusecs, though there were no gauging stations operating in either area during the year.

All three quantities so far discussed may show considerable variations from one year to another at a given locality. The quantity mapped in Fig. 4, however, is more likely to be conservative and to reveal essential and persistent differences between one part of Britain and another. This quantity has for twenty years or more been discussed by French geographers under the name *coefficient d'écoulement*, for which it is suggested that an appropriate English term would be 'discharge ratio'. It is simply the ratio R/P expressed as a percentage. When mapped it shows a wide variation (75/12·7 = 5·9) which expresses the combined effects of two fundamental geographical contrasts—that between upland and lowland, and that between the windward and leeward sides of the country. This is really the basic map of the hydrological characteristics of the country, and it is to be hoped that in future gauging stations will be established on the streams of Caithness, the west of Scotland, north-west and south-west Wales, Cornwall, Dorset, East Anglia, Lincolnshire and the north-east of England, to permit the blank areas of the map to be filled in.

When this has been done and mean values of the discharge ratio have been established for the whole of Britain over a period of years, we shall be possessed of a map which will reveal the very different endowment of the different parts of the country in respect of one of its basic resources—available surface water. Prof. W. G. V. Balchin has more than once in recent years stressed that over much of England the increasing demands for domestic and industrial water cannot long continue to be met locally, and has called for a stocktaking of our water resources as a first step to overall planning of water distribution and use[1]. It is urged here that maps of the kind now offered for the first time for Great Britain are basic documents for understanding our water situation and for planning for the future. It is very much to be hoped that the Surface Water Survey will itself, in future annual reports, undertake the presentation of its data year by year in this form, and in due time will undertake the preparation of maps of long-period monthly and annual means.

[1] Balchin, W. G. V., *Geography*, 42, 149 (1957); *Water and Water Engineering*, 61, 289 (1957).

THE McGILL–MONTREAL GENERAL HOSPITAL RESEARCH INSTITUTE

By Prof. J. H. QUASTEL, F.R.S.

THE McGill–Montreal General Hospital Research Institute, which has just celebrated the tenth anniversary of its foundation, is housed in an old three-story residence located on University Street, which is in the heart of Montreal, close by the McGill University buildings. It is situated very near the McGill Medical School, the Royal Victoria Hospital and the Montreal Neurological Institute.

The Institute arose as a result of a decision made in 1947 of the Board of Management of the Montreal General Hospital, upon the recommendation of its Medical Board, that the establishment of a laboratory devoted to the solution of medical problems by fundamental biochemical methods would be an important step for the development of medicine in Canada. The primary movers for the establishment of such an Institute were Dr. I. M. Rabinowitch, Dr. C. C. Birchard, Dr. B. S. Johnston and others, all members of the Medical Board of the Montreal General Hospital, who were convinced that medical progress to-day is greatly dependent on biochemical advances and achievements. When the Institute was inaugurated in 1948 it was the first of its kind to be established in a Canadian hospital.

Almost eight years after its inception, when the initial staff of five had grown to thirty, the Institute was incorporated into McGill University. The premises, which had been acquired by the Hospital from the University with funds given by Mr. T. H. P. Molson and the late H. W. Molson, reverted to McGill ownership. A special committee appointed by the Hospital considered that the scope of the Institute's activities would be broadened through a closer association with related McGill departments and McGill teaching hospitals. The incorporation was a natural consequence of the Institute's fundamental research work, which remains, however, intimately connected with practical medical problems.

The present somewhat ponderous name of the Institute recognizes a double loyalty, to the Hospital which brought the Institute into being, and with which a close association is maintained, and to McGill University, which embraces the Institute as part of its family of research units. As a member of the McGill Research 'family' the Institute has become a valuable training ground for students and for postgraduate investigators. The present writer is director of the Institute and professor of biochemistry in McGill University; two members of the staff of the Institute, Dr. P. G. Scholefield and Dr. E. H. Creaser, are assistant professors of biochemistry in the University.

The Institute has, at present, a staff of thirty-five, of whom sixteen are students working in the field of biochemistry for their Ph.D. degrees under the supervision of senior members of the Institute, and twelve are post-doctoral investigators. Both the students and post-doctoral investigators are drawn from various parts of the world. At present, as many as twelve different nationalities are represented. There are members, for example, from Canada, Britain, Australia, India, Pakistan, Japan, the Philippines, Hungary, Greece and Poland.

More than 150 original scientific articles have been published, from the Institute, by members of the staff since the Institute was opened about ten years ago. They are all in the biochemical field, and are concerned with investigations mostly undertaken because of their relation to medical problems. Some of the work lies in the cancer field, some in a field of study devoted to problems of the central nervous system, some in the fields of virology and microbial chemistry, and some of the work is associated with the subject of intestinal absorption. The problems that have been, and are being, investigated are concerned with the biochemical behaviour of cancer cells and of embryonic cells, with the effects of anti-metabolites on cell processes, with the mode of action of narcotics, anæsthetics, alcohols, and other substances affecting the behaviour of the nervous system, with the metabolic problems concerned with virus growth, with the mode of action of antibiotics, with the role of amino-sugars in metabolism, etc. These investigations, pursued at a fundamental level, make it possible for students in the Institute to acquire a broad experience of biochemical problems and techniques. Much of the work is necessarily enzymological in character, and a good knowledge of the biochemistry of enzymes is indispensable for the approach taken, in the Institute, towards its various problems. Radioactive techniques and procedures are followed in almost every phase of the work. Problems of nucleic acid metabolism and nucleotide synthesis, protein synthesis, phospholipid synthesis, all problems which are being actively investigated in the Institute, require their due quotas of carbon-14, phosphorus-32 and sulphur-35. Geiger counters operate on each floor of the old residence, and precautions have to be taken that no contamination by radioactive materials makes its appearance in the laboratories. Tumour transplantation in animals is carried out fairly extensively, as may be expected in an Institute which has to do with cancer problems, but the fact that transplantation of certain tumours into embryonated eggs is a successful procedure relieves to some extent the pressure on the animal house and the high cost of animal upkeep.

The Institute, now an active biochemical research centre, is very crowded, and there is no part of the old residence, in which the Institute is housed, that is not put to good use. It is well equipped, and it is surprising how well the many rooms of various dimensions serve as laboratories. Much of the laboratory furniture is home-made, and there is an excellent workshop that is indispensable for repair work as well as for the building of instruments.

Almost the entire work of the Institute is financed by grants and fellowships from a variety of organizations such as the National Cancer Institute of Canada, the Cancer Research Society, Inc., the National Research Council of Canada, the Rockefeller Foundation, the National Science Foundation and other scientific societies without the financial support of which the Institute could not survive. A number of commercial firms have also generously assisted the Institute; to these the Institute is very greatly indebted. The fact that the research work of the Institute depends so greatly on the financial help of many organizations, who support its work after due examination and appraisal of submitted projects, makes the task of organizing long-term research programmes a difficult one. It is greatly hoped that the Institute will one day be given a permanent endowment that will make it possible for the Institute to carry on part of its work without financial anxiety.

The Institute has been fortunate in the co-operation afforded it by the various departments of McGill University and its teaching hospitals, and also in the warm friendliness and active help of the chairman of the Biochemistry Department, Prof. D. L. Thomson. As Dr. F. C. James, principal of McGill University, and Mr. W. W. Ogilvie, president of the Montreal General Hospital, have justly stated, in a foreword to a brochure recently issued concerning the Institute, McGill University has long pioneered in many important fields of research. Since the days of Rutherford and Osler, McGill investigators, and others connected with the University, have contributed greatly to scientific and medical knowledge. The Institute is doing its best to maintain this tradition. Its success so far is due largely to the enthusiasm, devotion and hard work of its members, and it looks forward to a very productive future.

OBITUARIES

Dr. G. M. Bennett, C.B., F.R.S.

George Macdonald Bennett was born on October 25, 1892. His father, the Rev. J. E. Bennett, a great admirer of George Macdonald, the Scottish writer, had entered the Baptist ministry but established a private boarding school, Clacton College, towards the end of the past century, putting into practice many ideas which were then unorthodox but are now more generally accepted. Here Bennett received his early education; after the founder's death, the school was continued by Harold Picton, one of Ramsay's brilliant young men who had become associated with it in 1900. It is a tribute to this school, and perhaps more to the young Bennett's remarkable talents, that when he left it for East London (now Queen Mary) College in 1909 he embarked on an honours course in chemistry which he pursued by day while continuing with a correspondence course for an arts degree in the evenings and at week-ends. The resulting B.A. (1911) and B.Sc. (first-class honours, 1912) by the age of twenty foreshadowed the brilliance of his career.

In 1913 Bennett won an exhibition at St. John's College, Cambridge where he read chemistry, physics and mineralogy, taking a first class in both parts of the Tripos and being elected a Fellow of the College in 1917. He was then working under Prof. W. J. Pope, but his active mind ranged beyond the immediate war-time work, such as that on ββ′-dichlorodiethyl sulphide, and turned to crystallography, which he had learned under Hutchinson, and stereoisomerism.

Soon after the end of the First World War, Bennett worked for a short time with Strange and Graham, a firm of consulting chemists, and then was appointed a demonstrator at Guy's Hospital, London. From here, in 1924, he went as lecturer to the University of Sheffield, where in 1931 he succeeded Prof. W. Palmer Wynne as Firth professor. After seven years he returned to London to fill the vacancy caused by the retirement of Prof. Samuel Smiles at King's College, London, and soon had to cope with evacuation to Bristol. Here, although his department suffered from bombing, Bennett kept the teaching going and maintained an output of research.

In 1945, on the death of Sir John Fox, Bennett was appointed Government chemist. To some, this seemed a strange transition, but those who knew his wide knowledge and his mastery of detail were sure that he would justify the appointment—as he did, for the normal tenure was extended, but he did not live to complete the additional two years.

Space permits only a brief mention of a few of the lines along which Bennett worked, but these are selected to show his wide interests: surface tension and the constitution of liquids; isomerism of some ferrocyanides; reactivity of the chlorine atom in chloro-substituted sulphides; velocities of reactions of various types, particularly with reference to polar effects; glycols and thioglycols; stereoisomerism of disulphides, dioxides and related substances; valency angle of oxygen and of sulphur; crystal form of anhydrous citric acid; configuration of heterocyclic compounds; formation of large-ring sulphur compounds; liquid crystals; mechanism of nitration.

Bennett received the degrees of Ph.D. of London and M.A. and Sc.D. of Cambridge. He was elected to the Royal Society in 1947 and was appointed a Companion of the Bath in 1948. He was among the first old students to be made a Fellow of Queen Mary College. He was an honorary secretary of the Chemical Society from 1939 until 1946, having served on the Council during 1929–32, and was vice-president from 1948 until 1951. He served the Royal Institute of Chemistry on the Council for two years, as examiner for five years, and as vice-president for two years.

In 1918 Bennett married Doris Laycock, a Cambridge graduate, and her tragic death at Christmas 1957 from a rapid form of cancer no doubt aggravated the heart trouble from which he died suddenly and peacefully on February 9, 1959. He combined great gifts with humility and kindliness.

A. D. Mitchell

Dr. H. D. K. Drew

Harry Dugald Keith Drew died in London at the end of December at the age of seventy-two. He was educated at Queen Elizabeth's School, Barnet, and at Birkbeck College, London, graduating B.Sc. in 1910. His active professional career as a chemist began in 1919 when he joined G. T. Morgan, then professor of chemistry in Birmingham, as research assistant, after war service in the R.N.A.S. In 1922 he was appointed to the teaching staff of the University of Birmingham as lecturer in chemistry; in 1930 he became reader in organic chemistry in the University of London at Queen Mary College, a post which he held until he retired in 1947.

Drew's earliest published work was in collaboration with G. Senter and with A. McKenzie, and was concerned with the investigations on the Walden inversion which were then being carried out at Birkbeck College. In his later work, the interest in stereochemistry was maintained and developed along independent lines. The most striking of these researches was a re-investigation of Vernon's observations on the isomerism of the dialkyl telluronium dihalides, which were assumed to be *cis-* and *trans*-isomers resulting from a planar distribution of the valencies of tellurium. Drew established that the difference between the red α-dimethyl telluronium diiodide and the green β-compound is not one of *cis–trans* isomerism; the green compound has a salt-like character, Me_3TeI, $MeTeI_3$, whereas the red α-compound is Me_2TeI_2. He also inferred a tetrahedral distribution of the tellurium valencies. There were other investigations on tellurium and selenium organo-metal compounds, notable among these being the study of the interaction of tellurium tetrachloride with β-diketones.

In a series of papers from 1930 onwards, some in collaboration with the late Prof. W. Wardlaw and his school, the structure of platinum co-ordination compounds was examined in some detail and many of the inconsistencies and earlier conclusions corrected. Other topics which attracted Drew's interest were chemiluminescence and the metal lakes formed from orthohydroxy azo-compounds. While he was still on the staff in Birmingham, Drew was drawn into work with W. N. Haworth on the investigation of the ring structures of the sugars, and in this both he and E. L. Hirst played an important part in this revision of the then accepted structures.

In the late 1920's, Drew spent a period in Pregl's laboratory in Graz, and he returned enthusiastically in favour of the new system of micro-analysis of carbon compounds. He set up a laboratory for teaching Pregl's methods, and gave regular courses of instruction both in Birmingham and in London to undergraduate and graduate students. He also set up what was probably the first laboratory for the routine microanalysis of carbon compounds.

Drew was a man of many gifts and interests, among them an active interest in tennis and cricket, yet he never conquered his shyness and reticence to become well known even to his colleagues. The over-riding interest in his life was the practice of chemistry, and to those who had the opportunity of seeing him work at the bench, his skill with small amounts of material and his ability to extract pure crystalline products from the most unpromising material seemed uncanny. He was a man who practised his craft essentially for the satisfaction of accomplishment and not for any personal gain or reward.

W. J. Hickinbottom

NEWS and VIEWS

Royal Society of Edinburgh : New Fellows

At the ordinary meeting of the Royal Society of Edinburgh, held on March 3, the following were elected Fellows of the Society : Dr. S. Alstead, regius professor of materia medica, University of Glasgow ; Dr. H. Barnes, principal scientific officer, Marine Biological Station, Millport ; Dr. D. Borwein, lecturer in mathematics, University of St. Andrews ; Dr. A. F. Brown, lecturer in natural philosophy, University of Edinburgh ; Prof. R. Brown, professor of botany, University of Edinburgh ; Dr. H. E. Butler, principal scientific officer, Royal Observatory, Edinburgh ; Prof. R. Cruickshank, professor of bacteriology, University of Edinburgh ; Prof. J. Drever, professor of psychology, University of Edinburgh ; Mr. W. D. D. Fenton, chairman, Uganda Electricity Board ; Prof. J. C. Gunn, Cargill professor of natural philosophy, University of Glasgow ; Prof. A. A. Harper, professor of physiology, King's College, Newcastle upon Tyne ; Prof. A. Macdonald, professor of bacteriology, University of Aberdeen ; Dr. W. S. Mackenzie, lecturer in geology, University of Manchester ; Prof. R. H. Matthew, professor of architecture, University of Edinburgh ; Dr. T. A. Munro, physician-superintendent, Royal Edinburgh Hospital for Mental and Nervous Disorders ; Dr. E. M. Patterson, lecturer in mathematics, University of Leeds ; Prof. W. L. M. Perry, professor of materia medica, University of Edinburgh ; Dr. D. L. Pursey, lecturer in mathematical physics, University of Edinburgh ; Dr. J. H. Sang, assistant director, Agricultural Research Council Poultry Research Centre, Edinburgh ; Dr. R. J. Scothorne, senior lecturer in anatomy, University of Glasgow ; Dr. M. A. H. Tincker, principal, North of Scotland College of Agriculture, Aberdeen ; Dr. D. Traill, research director of I.C.I., Ltd. (Nobel Division), and director of research ; Prof. A. D. Walsh, Baxter professor of chemistry, Queen's College, Dundee ; Dr. E. W. Walsh, senior lecturer in physiology, University of Edinburgh ; Mr. K. Williamson, migration research officer, British Trust for Ornithology, Oxford.

Chemical Engineering at Cambridge : Prof. T. R. C. Fox

Many will learn with surprise and dismay that Prof. T. R. C. Fox has decided to relinquish the Shell chair of chemical engineering in the University of Cambridge, due to ill-health. When the chair was established in 1946 the number of university departments in chemical engineering in Britain was woefully small and the electors for the professorship had some difficulty in finding the right man for a position that would unquestionably have a great influence on the teaching of chemical engineering in Britain. Prof. Fox had taken a keen interest in the work of this Department from the first mention of its setting up by the Shell Company, and with his background of four years in Imperial Chemical Industries, Ltd., at Billingham, followed by a period as a lecturer in mechanical engineering at Cambridge, Prof. Fox, at the early age of thirty-four, was an outstanding choice. He was already well established at Cambridge, having been an undergraduate at Jesus and a Fellow of King's, and the past twelve years have shown how well this choice has worked out. The Department has built up a reputation in chemical engineering throughout the Western world, and several chairs of chemical engineering in British universities are now occupied by men who have served with Prof. Fox at Cambridge. All those who know him will trust that his health will soon be fully restored.

Prof. P. V. Danckwerts, G.C., M.B.E.

Prof. P. V. Danckwerts was one of the first of those to take part in the building up of the Shell Department of Chemical Engineering at Cambridge, and it does not detract from the feeling of loss that Cambridge will experience in losing Prof. Fox to say that it is a very pleasant thought that the chair will be occupied by Prof. Danckwerts, who is forty-two. His scientific education was begun at Oxford, and after war service in the R.N.V.R., during which he was awarded the George Cross, he spent some time at the Massachusetts Institute of Technology. He returned from there in 1948, in order to take up a position at Cambridge in the new Department, and later joined the U.K. Atomic Energy Authority as deputy director of research and development in the Industrial Group. In 1956 he was invited to take up a professorship in the Department of Chemical Engineering at the Imperial College of Science and Technology, London. During his stay at the Imperial College he has been actively concerned with the re-organization of the syllabus for the teaching of chemical engineering in the University of London and he will bring much experience, both in modern industry and in the teaching of chemical engineering, to Cambridge.

Department of Anthropology, Government of India : N. K. Bose

Mr. Nirmal Kumar Bose, reader in anthropogeography in the University of Calcutta, has been appointed director of the Anthropological Department, Government of India. He took his B.Sc. in geology and his M.Sc. in anthropology in the University of Calcutta. He is well known for his work on the dating of Indian architecture, where documentary evidence is seldom available, and there has been an unfortunate tendency to base dates on a highly hypothetical history of Indian æsthetics. He has done much to introduce more objective methods. He has discovered several sites with palæolithic artefacts. He has worked, and directed the work of others, among tribal peoples. These peoples number about twenty-five millions, and he and his pupils have worked not only on their cultural anthropology but also on their demography. While a few tribal communities have been intensively studied, no comprehensive survey of this vast population exists, and Mr. Bose is keenly aware of the challenge which they offer to a State which has abjured imperialistic methods.

Mr. Bose has also worked on the cultural anthropology of more civilized sections of the Indian people, including certain of their festivals, and on the social changes which are now occurring in rural Bengal. Some of this work is available to readers of English in his book, "Cultural Anthropology", and in the pages of *Man in India*, of which he is an editor, but much of it has been published in Bengali. Like the English scientists of the seventeenth century, Indian scientists are now faced with the dilemma of publishing in an international language or attempting to educate their own countrymen. Mr. Bose, with his emphatic belief that anthropology begins at home, has often chosen the latter alternative, and for this reason readers of English may under-estimate his work. Mr. Bose has been a successful and much-loved teacher, and may therefore hope to succeed in his intention to establish a working relation between the Department and the universities.

Artificial Planet 2

THE United States *Pioneer* 4 space vehicle, launched from Cape Canaveral in Florida at 05.10 hr. U.T. on March 3, travelled past the Moon to become the second artificial planet of the Sun. The launching missile had four stages of propulsion: the first stage was the United States Army *Juno* 2 rocket, and the later stages were made up of clusters of solid-fuel rockets. The vehicle, conical in shape and with a mass of 13 lb., carried instruments to measure the intensity of the corpuscular radiation in the vicinity of the Earth, and a photo-electric sensor which, if the vehicle passed close enough, was to register light from the Moon. A radio transmitter with a frequency of 960 Mc./s. was also carried, with batteries to last for four days. By means of these signals the vehicle was successfully tracked by the Jodrell Bank radio telescope to a distance well beyond the Moon.

The vehicle, which attained an initial speed of 6·91 miles per second, passed the Moon at a distance of about 37,000 miles at 22.24 hr. U.T. on March 4, some 41 hr. after it was launched. It then flew on into an orbit around the Sun, and its distance from the Sun is expected to vary between 91·7 and 102 million miles. Its perihelion distance is, like that of Artificial Planet 1 (see *Nature*, **183**, 83; 1959), almost the same as that of the Earth, and the orbital plane is inclined at only a very small angle to the ecliptic. The orbital period about the Sun is expected to be 392 days; with the first perihelion on March 17.

New Laboratory for Research on Plutonium

THE Battelle Memorial Institute is to erect a new laboratory designed especially for studies of plutonium at its Nuclear Research Center outside Columbus, Ohio. It is hoped that the laboratory will be in operation by midsummer. It will be particularly well adapted to the study of plutonium as a reactor fuel material. This is a natural extension of the Institute's work in reactor and fuel element metallurgy, which dates back to 1942. The laboratory will be used by both governmental and industrial groups. Research at present planned for the laboratory will focus on alloys and compounds of plutonium, as well as plutonium itself. The new one-story building will provide 1,440 sq. ft. of space and will contain a variety of conventional and specialized equipment for the development of plutonium fuel elements. The research reactor, hot cells and critical assembly laboratory in operation at Battelle's Nuclear Center will provide supporting services and facilities for workers in the new plutonium laboratory.

Cyanamid European Research Institute, Geneva

CYANAMID, one of the leading chemical and pharmaceutical manufacturers of the United States, has recently completed plans for setting up a basic research laboratory, to be known as the Cyanamid European Research Institute, Inc., to be situated in Geneva. The new scientific centre, which is to employ British, French, German, Swiss and other European scientists, will be solely devoted to long-range research in the chemical and biological sciences. The Institute has acquired an 8½-acre tract of land in the Cologny section overlooking Lake Geneva. This property includes a large residence which will be converted and extended for use as laboratories.

Production and Marketing of Radioactive Isotopes in Britain

To meet the increasing demand for radioactive isotopes throughout the world, the U.K. Atomic Energy Authority has re-organized the production and marketing of isotopes, which has hitherto been shared between the Radiochemical Centre at Amersham and the Isotope Division at Harwell. It has been decided to widen the scope of the Radiochemical Centre, under the direction of Dr. W. P. Grove, to form a single comprehensive organization for producing and marketing all such isotopes. The Radiochemical Centre has its headquarters and principal laboratories at Amersham and will have irradiation facilities at Harwell and at other sites of the U.K. Atomic Energy Authority.

The re-organization is already effective, but users of radioisotopes should continue, for the time being, to order their requirements from Amersham or Harwell. Research into the properties of isotopes and new applications of them and their radiations will be continued at the Isotope Research Division, Harwell, and at the Wantage Radiation Laboratories. This Division will continue to operate the Isotope School; both the Radiochemical Centre and the Isotope Research Division will remain part of the Research Group of the Atomic Energy Authority.

Agricultural Aviation

THE use of aircraft in agriculture and forestry is by no means new and has made especially outstanding contributions to food output in newly developed areas. The aeroplane has also had some influence on traditional farming methods, and there is no doubt that the use of aircraft in farming will increase in the future. It is therefore appropriate that a new periodical, *Agricultural Aviation* (1, No. 1. Pp. 23. Published quarterly. Subscription rates per annum: Europe, 24*s*., 1,500 French francs; United States and Canada, 3.50 dollars. The Hague: E.A.V. v.d. Boschstraat 4, 1959), should be entirely devoted to this topic. It is published by the European Agricultural Aviation Centre at The Hague, but the contents are by no means limited to agricultural aviation in Europe. On the contrary, it should serve as a source of up-to-date information on a world-wide scale, and for this reason it is published in two editions, in English and French, respectively. The first issue contains two papers from member countries. One, by G. H. Brenchley, of the British National Agricultural Advisory Service, gives an account of trials carried out over the past two years in the control of potato blight by aerial spraying. The second, by G. Schumacher (Germany), concerns the control of leaf cast in common pine. There are also descriptions of new types of agricultural aircraft and equipment and extracts from recent agricultural aviation literature.

Selborne Society Library

THE Selborne Society has deposited its library, which was started in 1895, in the care of the Ealing Public Libraries, and thus made it available to all. The catalogue (pp. 34. Ealing: Central Library, 1958) has been compiled by the staff of the Ealing Reference Library and is arranged in six sections: manuscripts; editions of the "Natural History of Selborne"; other works by Gilbert White; works on Gilbert White and Selborne; books on natural history in general; and other books. It is hoped that the collection, already supplemented by the larger stock of Ealing Public Libraries, will be further augmented by additions from the Society and the public.

Transvaal Museum, Pretoria

THIS well-known Museum, in its annual report for the year ending March 31, 1958 (pp. 48. Pretoria: Transvaal Museum, 1958), records progress in its educational and scientific activities. Lack of space, though a familiar complaint, is now a very serious matter and constitutes a grave hindrance to the efficient functioning of the Museum. Several field trips have been undertaken during the year and in consequence much valuable material has accrued to the collections. The staff have been active in research and publication and continued to give freely of their time in lectures, talks and demonstrations to local cultural organizations. Temporary exhibitions were re-instituted during the year and placed on display each month in the entrance hall. Objects given to President Kruger, but not actually used by him, were transferred from the President's Residence and displayed in cases.

"Flora Europaea"

IN a short publication, Dr. V. H. Heywood has set out basic ideas and information relating to a projected new European Flora ("The Presentation of Taxonomic Information: A Short Guide for Contributors to Flora Europaea". Leicester University Press, 1958). In a foreword, Prof. T. G. Tutin, who is chairman of the Organizing and Editorial Committee, has explained that the main aim of "Flora Europaea" is to consolidate and correlate previous work. This comprises the studies and compilations of more than two centuries and involves contributions from some 20–30 countries. It is hoped to produce a well-balanced, critical survey, in which all relevant information concerning angiosperms, gymnosperms and pteridophytes will be assimilated and presented within a uniform framework. The Flora is intended to be of broad usefulness, not only for taxonomists, but also for other professional botanists, agronomists, foresters, and so on. It is expected that it will be completed within a period of about 12–15 years and that it will comprise three or four volumes. In the pamphlet under consideration, full information is given regarding standard procedures to be used in the preparation of the Flora. The sponsors are the Linnean Society of London, and the secretary of the Organizing and Editorial Committee is Dr. V. H. Heywood, curator of the Herbarium, University of Liverpool.

The Indian National Scientific Document Centre

THE demands on the services provided by the Indian National Scientific Document Centre, for which the Council of Scientific and Industrial Research provided Rs. 4,81,000, compared with Rs. 1,50,000 in 1953–54, increased by 15·2 per cent in 1957–58, and 6,202 out of 6,994 requests were met (Insdoc Report, 1957–58. Pp. ii+22. New Delhi: National Physical Laboratory of India, 1958). These included compilation of 126 bibliographies, 39 technical inquiries and the supply of copies of 5,290 articles, 44·2 per cent coming from Delhi libraries and 15·6 per cent from other Indian libraries. Requests were also received for 305 photocopies of diagrams for research papers, etc., and 441 translations were supplied out of 507 requested. The size of the Insdoc List of Current Scientific Literature has been increased and from January 1958 the *Bibliography of Scientific Publications of South and South East Asia* is being published monthly.

Snowdonia

"SNOWDONIA", issued for the National Parks Commission as National Parks Guide No. 2 (pp. xii+104+17 plates. London: H.M. Stationery Office, 1958. 5*s*. net), was prepared by the Snowdonia Park Joint Advisory Committee under the editorship of E. Vale. It includes descriptions of the geology of the Park by T. C. Miller, its plant life by Prof. P. W. Richards, and its fauna by Prof. F. W. R. Brambell, as well as notes on the principal antiquities within the Park, on mountaineering and on country-going and communications. There is also a full topographical description of the Park. The guide-book is well illustrated, and with a sufficiency of maps, an adequate bibliography, as well as lists of useful addresses, it should fill two important functions: the clarification of public understanding as to the purpose and functions of a national park; and the assistance of those who visit the Park. The National Parks Commission and the Snowdonia Park Joint Advisory Committee are to be congratulated on a first-rate piece of work, admirably designed for its purpose.

Availability of Technical Films used at the Geneva Conference

FORTY-FIVE technical motion pictures first shown last September in Geneva at the Second International Conference on the Peaceful Uses of Atomic Energy are now available for loan and sale from the U.S. Atomic Energy Commission. The 16-mm. films, most of which are in colour, cover major nuclear applications and research activities. They were sponsored by the Atomic Energy Commission, its industrial and university contractors and, in a few cases, by private industrial organizations. Most of the films will be lent on request to industry, advanced educational institutions, research organizations, Government agencies, etc., by the eleven film libraries of the Atomic Energy Commission, each of which serves a specific geographical area within the United States.

All forty-five Geneva films are also available for sale from the following sources: Byron, Inc., 1226 Wisconsin Avenue, N.W., Washington 7, D.C.; Capital Film Laboratories, Inc., 1905 Fairview Avenue, N.E., Washington 2, D.C.; Consolidated Film Industries, 959 Seward Street, Hollywood 38, California. The Washington and field libraries also have about seventy other, less technical, films appropriate and available for loan to schools, industry, and other audiences of laymen. Inquiries about the loan and sale of films to foreign users should be sent to the Public Information Service, U.S. Atomic Energy Commission, Washington 25, D.C. All films are available now in English for sale abroad, and will soon also be available in French, Spanish or Russian. An overseas loan programme is being arranged through the United States Information Agency.

Gas Chromatography

A SPECIAL group has been formed under the auspices of the Analytical Chemistry Section of the International Union of Pure and Applied Chemistry to make recommendations for a standard terminology in gas chromatography. The group consists of: Dr. D. Ambrose (Great Britain) (*chairman*), Dr. A. T. James (Great Britain), Prof. A. I. M. Keulemans (Netherlands), Dr. E. Kovats (Switzerland), Dr. R. Röck (Germany), Dr. C. Rouit (France) and Dr. F. H. Stross (United States). As a basis for their work, the group plans to take the two papers, "Presentation of Gas–Liquid Chromatographic Retention Data", by D. Ambrose, A. I. M. Keulemans and J. H. Purnell (*Analyt. Chem.*, 30, 1582; 1958), and "Terms and Units in Gas Chromatography", by H. W. Johnson and F. H. Stross (*ibid.*, 30, 1586; 1958). Comments about these papers or related subjects will be welcomed from those interested, and correspondence can be addressed to Dr. D. Ambrose, National Chemical Laboratory, Teddington, Middlesex, or to any member of the group.

Indian Society of Genetics and Plant Breeding

AT the nineteenth annual general meeting of the Indian Society of Genetics and Plant Breeding held on January 23, at New Delhi, the following were elected as office-bearers of the Society for 1959: *President*, Dr. R. H. Richharia; *Vice-Presidents*, Dr. A. B. Joshi, Prof. P. N. Bhaduri; *Secretary*, Dr. M. S. Swaminathan; *Treasurer*, Dr. N. L. Dhawan; *Editor*, Dr. B. P. Pal; *Councillors*, Prof. P. Maheshwari (Northern Zone), Dr. E. K. Janaki Ammal (Mid-Eastern Zone), Dr. S. K. Mukherjee (Eastern Zone), Dr. A. R. Gopal-Ayengar (Central Zone), Dr. T. R. Mehta (Western Zone), Dr. N. R. Bhat (Southern Zone). It was decided at the meeting that henceforth papers on animal genetics and breeding should be included within the scope of the *Indian Journal of Genetics and Plant Breeding.*

Postgraduate Awards in Agricultural Research

THE Agricultural Research Council has recently issued a useful booklet giving details of the Research Studentships and Fellowships which the Council is offering in 1959. The booklet also gives information about the openings in the agricultural research and advisory services. Two veterinary research fellowships, tenable for three years, will be open to workers holding a veterinary qualification who have had not less than three years experience in veterinary research, and three junior agricultural research fellowships, also tenable for three years, will be open to honours graduates with not less than three years postgraduate experience. In addition, the Council is again offering up to thirty postgraduate studentships in agricultural research including veterinary training grants, applications for which should reach the Council by March 31. Further information and a copy of the booklet can be obtained, free of charge, from the Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1.

Eclipse of the Moon, March 24

THERE will be a partial eclipse of the Moon on March 24, visible at Greenwich. The circumstances are:

Moon enters penumbra	17h. 56m.
Moonrise at Greenwich	18h. 11m.
Moon enters umbra	19h. 16m.
Mid-eclipse	20h. 11m.
Moon leaves umbra	21h. 07m.
Moon leaves penumbra	22h. 27m.

The greatest fraction of the Moon's apparent diameter obscured by the umbra will be 0·27.

Announcements

DR. FRANCIS H. CARR, formerly chairman of British Drug Houses, Ltd., has been awarded the Society Medal for 1959 of the Society of Chemical Industry; this Medal is awarded not more than once every two years for conspicuous services to applied chemistry or to the Society.

LORD HAILSHAM, the Lord President of the Council, is to open the new Warren Spring Laboratory of the Department of Scientific and Industrial Research, at Stevenage, on June 29. Its initial programme will include work on mineral processing, the synthesis of oils and chemicals from carbon monoxide and hydrogen, and research aimed at the suppression of atmospheric pollution. Much of this work will be of a chemical engineering character and will require basic chemical engineering research to be undertaken in parallel with it. For the time being, research on atmospheric pollution will continue at the Atmospheric Pollution Division, Warren Spring Laboratory, River Way, East Greenwich, London, S.E.10.

A CONFERENCE on Silicon Carbide, sponsored by the U.S. Air Force Cambridge Research Center, will be held at John Hancock Hall, Boston, Mass., on April 2 and 3. Details can be obtained from the chairman, Dr. J. R. O'Connor, Materials Research Unit, Air Force Cambridge Research Center, Bedford, Mass.

THE symposium on vaccination against tuberculosis with non-living vaccines, which was to have been held in Florence during April 5–7 (see *Nature*, January 17, p. 154), has been postponed until September. Further information can be obtained from Prof. G. Buonomini, Centro per la Vaccinazione Antitubercolare, Universita di Pisa.

A SYMPOSIUM on Molecular Structure and Spectroscopy will be held at the Department of Physics and Astronomy, Ohio State University, during June 15–19. For further information, or for a copy of the programme when it becomes available, write to Prof. R. A. Oetjen, Department of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

THE annual meeting of the Air Pollution Control Association will be held at the Hotel Statler in Los Angeles, California, during June 22–26. At the technical sessions papers will be presented by outstanding authorities covering the control of air pollution. Proceedings, incorporating copies of all technical papers, will be published.

ERRATUM. A mistake was made in the manuscript of the communication entitled "Discrepancy between the Distributions of Iodine in Human Serum when estimated by Iodine-131 and Iodine-127" by Drs. S. C. Werner and R. J. Block (*Nature*, February 7. p. 406); in Table 1, col. 2, for "33" read "3".

DARWIN, WALLACE AND LINNÆUS CELEBRATIONS IN SINGAPORE

A CONGRESS was held in Singapore during December 2–9 to celebrate "the Centenary of the formulation of the theory of Evolution by Charles Darwin and Alfred Russel Wallace and the Bicentenary of the publication of the tenth edition of the 'Systema Naturæ' by Linnæus".

It was particularly fitting that this Congress should have been held in Singapore for, although it honoured equally the works of Linnæus, Charles Darwin and Alfred Russel Wallace, it directed special attention to the work of Wallace, who was one of the greatest biologists ever to have worked in south-east Asia. Although it was inspired and run by a small body of organizers without any form of public recognition, and although it was financed solely by response to personal appeals, the Congress achieved international status and standards. Much credit goes to the organizers, the sponsors, and all who participated.

Twenty-three scientists visited Malaya to participate in the Congress, from Britain, Holland, India, Ceylon, Thailand, Sarawak, Hong Kong, Formosa, Australia, Hawaii, Korea and the United States. These joined with Malayan and Singaporean scientists to form a group of some sixty persons who contributed scientific papers, exhibitions, evening discourses and film shows, and attended excursions into primary forest and mangrove swamps.

Nearly six hundred members were enrolled, and attendances at meetings were consistently high. The papers delivered were of high quality and, due to good chairmanship, the meetings kept to the time programme, and adequate time was available for some stimulating discussions.

The Chief Minister of Singapore, Tun Lim Yew Hock, welcomed the visiting scientists and members of the Congress at an inaugural ceremony, which was held at King Edward VII Hall. Prof. J. B. S. Haldane (Calcutta) was then installed as president of the Congress by the vice-chancellor of the University of Malaya, Dr. A. Oppenheim. Prof. Haldane then delivered his presidential address—"The Theory of Natural Selection To-day"—to a large and colourful gathering of members and distinguished guests. The president emphasized the stimuli gained by Linnæus, Darwin and Wallace through working in peripheral areas where lack of knowledge was a challenge. He suggested that the next major biological advance may well come for similar reasons from peripheral places such as Singapore, or Calcutta, where this challenge still remains and where the lack of complex scientific apparatus drives biologists into different and long-neglected fields of research [see p. 710 of this issue of *Nature*].

The first scientific session constituted a general introduction to the Indo-Malayan Region. R. Ho (Malaya) reviewed the geological history and present geographical features of the region; E. J. H. Corner (Britain), official representative of the Royal Society, directed attention to the need for work on the rain forests of Malaysia before it was too late, and illustrated the inadequacy of our present knowledge of the area by a series of fundamental questions that remain unanswered as yet. Tom Harrisson (Sarawak) proceeded to review the changes that have occurred in Sarawak since Wallace's time, some of which were attributable to Wallace himself, such as the regrettable decimation of the orang-utan.

The papers presented in the section on evolution reflected the broad spectrum of modern non-experimental evolutionary studies. The phylogeny of fishes was considered by A. Fraser-Brunner (Singapore), of lamellibranchs by R. D. Purchon (Singapore), and of the agnathan head by R. Strahan (Hong Kong). Problems of comparative anatomy were dealt with by D. D. Davis (Chicago) and D. Barker (Hong Kong). Zoogeography was represented by a paper by J. L. Gressitt (Honolulu). Perhaps most significant was the strong emphasis on the operation of evolutionary mechanisms within small natural populations, representing promising attempts to document from Nature the mathematical models of Fisher and Wright and the laboratory experiments of Dobzhansky and others. Of a total of nine papers, three—by G. S. Carter (England), H. G. Andrewartha (Australia) and W. S. S. Van Benthem Jutting (Holland)—were concerned with one aspect or another of this important problem.

The session on parasitology and entomology opened with a review by A. A. Sandosham (Singapore) of the evolution of the parasitic mode of life. R. Hoeppli (Singapore) gave an entertaining review of the growth of knowledge of tapeworms, illustrating the value of the sadly neglected historical approach. J. R. Audy (Malaya) discussed evolution of parasitism in trombiculid mites; W. W. Macdonald (Malaya) reviewed the distribution and some evolutionary aspects of Malayan mosquitoes with special reference to breeding places, some species being closely associated with man through adoption of man-made breeding places. This made an interesting comparison with the discussion by L. W. Quate (Honolulu) of different patterns of dispersal and of evolution in the islands of Micronesia by two families of Diptera—empids, largely airborne, and psychodids, largely dispersed by man. J. R. Audy, in a second paper, noted that many parasites are habitat-specific rather than host-specific, or depended for transfer on particular features of host-behaviour, and stressed the value of parasites as 'ecological labels' to give ecological information about their hosts. Finally, Kim Hon-Kyu (Korea) described the life-history and host relationships of a wasp parasitic on a moth which is a potential source of silk in Korea.

At the session on zoogeography, Wallace's Line was not regarded as constituting a significant frontier between two distinct faunal areas either by J. L. Gressitt (Honolulu), who considered the insects, or by L. G. Brongersma (Holland), who has studied the reptiles. In both cases transition was noted rather than abrupt change. H. E. McClure (Malaya) discussed the migration of birds in the Far East and indicated the known flight routes over a wide area. In the absence of any programme of ringing of birds, little is known of the distances travelled by individuals.

Of the six papers presented on terrestrial ecology, three were concerned with particular ecological phenomena or particular animal species and the others with the broader point of view usually called 'natural history'. In the animated discussions that followed papers and occurred informally at other times, the most notable feature was a general agreement that the fauna of the tropical rain forest, because of its extreme ecological complexity, is still so poorly understood that it can best be studied from the 'natural history' point of view, for the present leaving precise quantitative studies and intensive testing of ecological principles to workers in simpler environments in other parts of the world.

The first two papers in the session on freshwater ecology, by W. S. S. van Benthem Jutting (Holland) and D. S. Johnson (Singapore), dealt with aspects of the distribution of non-marine molluscs of the Mollucas and of Indo-Pacific freshwater organisms, respectively. The latter paper, which queried the validity of the concept of a separate oriental region, provoked an interesting discussion. A paper on productivity of fishponds and similar bodies of water by G. R. Fish (Malaya) elicited a lively and informative discussion. Other papers included colonization of freshwater habitats by aquatic insects by C. N. Fernando (Ceylon) and the study of breathing behaviour of salamanders and of the climbing perch by H. Spurway (Calcutta).

The genetics section opened with four papers on human polymorphism in South-east Asia. F. Vella (Singapore) described abnormal hæmoglobins in local Chinese, Indians, Malays and others; thalassæmia was not uncommon in Chinese and Malays, sometimes associated with abnormal hæmoglobins. I. Polunin (Singapore) discussed wide variations in blood-group frequencies in different settlements of the same aboriginal tribe, probably due to genetic drift. D. C. Rife (Bangkok) presented dermatoglyphic evidence that Thai people are closely related to Chinese, while E. McEvoy-Bowe (Singapore) described his work on β-amino-*iso*butyric acid excretion in local peoples and gave details of his useful new method for the accurate estimation of urinary amino-acids in chromatograms.

Among later papers, that of C. F. Hickling aroused special interest. He described hybridization experiments with important food-fish of the *Tilapia mossambica* group. Some crosses led to all-male F_1 progeny with marked hybrid vigour, growing about twice as fast as the parent stocks. S. K. Roy (Calcutta) described the wide polymorphism of Indian cattle and buffaloes, with special reference to nipple number. A. G. Searle (Singapore) showed that threshold characters were remarkably common in local wild mice as well as in domesticated animals. He suggested that anencephaly in humans was also due to a threshold mechanism. The last contribution, by Helen Spurway and A. Kumar (Calcutta), on variation under domestication, contained some intriguing suggestions; for example, that "we have not domesticated plants, but they have domesticated us". The chairman (J. B. S. Haldane, Calcutta), in summing up, pointed out the great opportunities in tropical countries for work on human genetics and on cultivated plants and animals in the early stages of domestication.

The section on anthropology covered a wide range of subjects. V. Thambipillai (Singapore) described the physical types of man now living in Malaya, while G. C. Whittow (Singapore) and T. S. Lee (Singapore) both discussed physiological adaptations to life in the humid tropics. I. Polunin (Singapore) concluded that the falling birth-rate in the Muruts of North Borneo may arise chiefly from infectious disease following pregnancy. Tom Harrisson (Sarawak), drawing vividly on his own experiences, gave a stimulating review of the basic problems of living in the jungle. M. Benanzio (Singapore) commented on the high incidence of 'Mongolian spot' in certain populations in Sumatra.

The most interesting contribution in the session on systematics was perhaps the description and discussion by D. Barker (Hong Kong) of the interesting crustacean *Thermosbaena mirabilis*, representative of the small and often neglected order Thermosbaenacea. Further papers were presented by D. S. Johnson (Singapore), P. J. van der Feen (Holland) and L. G. Brongersma (Holland) on a variety of topics ranging from variation in freshwater prawns to the fauna of New Guinea.

E. J. H. Corner (Britain) opened the botanical session and concluded from an attempt to reconstruct the evolution of tropical broad-leaved forest that it was perfected at the beginning of the Cretaceous period before there were, apparently, modern birds and mammals such as now use it. H. B. Gilliland (Singapore) directed attention to the importance of the orchid seedling, with its changes in symmetry, to plant morphology. J. Wyatt-Smith (Malaya) suggested that the vegetation of Pulau Pangkor in the Malacca Straits was destroyed by the eruption of the Toba Lake volcano and that the new flora is of oceanic type, depending mainly on wind- or animal-dispersal of seeds. E. A. Rosenquist (Malaya) discussed the physiology and genetics of palms; G. A. Prowse (Malaya) described new species of Flagellata which provide important sources of fish-food in the fish ponds in which several are characteristic. Yen Yo-Min (Singapore) described the discovery of six *Cercospora* diseases on sugar cane in Formosa. S. K. Roy (Calcutta) gave an account of variation of leaves on the same plant in *Nyctanthes arbor-tristis*. A. Johnson (Singapore) discussed the distribution of Malayan mosses and green seaweeds, an important extension of Malaysian phytogeography. Finally, A. Santiago (Malaya) spoke of the importance of agricultural genetics in applied botany and the shortcomings of reliance on vegetative propagation.

The week-end excursion to Bukit Timah gave a valuable introduction to Malayan rain forest for those to whom it was new, since Bukit Timah is a most important type locality for plants and animals in Malaysia. This is now a carefully protected nature reserve of some 150 acres.

An all-day excursion began with exploration of the mangrove swamp in the Pandan Nature Reserve. The party saw many interesting species, including some large mud-skippers (*Periophthalmus*), one of which was being killed and consumed by the common dog-faced water snake (*Cerberus*).

The scientists visiting Malaya were entertained at a cocktail party at the residence of the chairman of the Organizing Committee on the first evening. On subsequent evenings there was a diversity of public functions, which were particularly appreciated by the many local members who were not free earlier in the day. There were public lectures by J. B. S. Haldane (Calcutta), J. R. Hendrickson (Singapore) and by H. Munro Fox (Britain), the representative to the Congress from the British Association for the Advancement of Science. There were two evenings of film shows; the first consisted of films taken in Sarawak and presented with a lively running commentary by Tom Harrisson (Sarawak), while the second included films taken in New Guinea and presented personally by L. G. Brongersma (Holland), one taken in North Borneo and presented personally by I. Polunin (Singapore), and one by the Malayan Film Unit, which was introduced by R. D. Purchon (Singapore).

The British Council prepared a photographic exhibition of Darwiniana specially for the Congress, and this was displayed in the Art Museum of the University of Malaya, where it was the object of considerable interest. The exhibition was afterwards displayed in Kuala Lumpur and, so that the maximum benefit should be gained from its preparation, it was then sent on tour; part was sent to Colombo for the meeting of the Ceylon Association for the Advancement of Science and the remainder was sent first to Kuala Lumpur and then to Bangkok. On its return it will be presented to the Department of Zoology, University of Malaya, through the generosity of the British Council.

A bibliographic exhibition was organized by the Foreign Service of the United States and consisted of about three hundred biological publications the majority of which were sent from America specially for the Congress, and the greater part of which has been most generously presented to the library of the University of Malaya. This exhibition was augmented by a smaller number of British works, loaned for the occasion by the Singapore agents of various British publishing houses.

After the Congress, an excursion lasting a fortnight was conducted which traversed the west-coast districts of Malaya as far as Perlis. Special attention was paid to freshwater habitats; the variety observed ranging from rice-fields to torrent-streams, and from acid blackwaters to limestone pools. In addition, visits were made to the Fish Culture Research Station at Batu Berendam, Malacca (*Nature*, 183, 287; 1959); to the Rubber Research Institute and the Institute for Medical Research at Kuala Lumpur; and to the Fisheries Department and the Bayan Lepas Experimental Farm at Penang. The opportunity was taken to visit and collect from a number of limestone hills and caves.

The post-Congressional field trip to the King George V National Park in the depths of Pahang brought together nine biologists from four continents, whose interests ranged through taxonomy, zoogeography, ecology and evolution. The base of the party was at Kuala Tahan, where they lived in a lodge of the National Park, with adjacent facilities in the Forest Research Laboratory of the Department of Zoology, University of Malaya. The party spent six days walking and collecting through a number of different types of vegetation. They inspected the pattern of quadrats laid out by the Department of Zoology as a part of its long-term programme of ecological research in the jungle. Valuable suggestions were received from the visiting scientists regarding methods of approach and priorities in this programme.

Arrangements were made for some of the visitors to lecture at Kuala Lumpur in the Federation of Malaya, to widen the impact of the Congress. Prof. J. B. S. Haldane gave the substance of his lecture on natural selection and genetics, previously delivered in Singapore, to a special meeting of the Malayan Nature Society. In addition, the Malayan Scientific Association convened a special meeting, at which H. Waring (Australia) discussed the studies, which he had previously presented in Singapore, on the marsupial quokka. H. G. Andrewartha (Australia) described some extremely interesting experiments on mice still in progress in Adelaide. These bear directly on intra-specific elements influencing reproduction and may help to interpret the regulation of population densities. L. G. Brongersma showed and commented on the ciné film of his zoological field work in Dutch New Guinea. The visitors saw the forest reserves and the laboratories of the Institute for Medical Research and of the Rubber Research Institute.

The proceedings of the Congress were covered by the Malayan Film Unit, and it is anticipated that a documentary film will be released in the near future.

Any credit balance remaining in the hands of the chairman of the Organizing Committee will be applied as an endowment to provide a book prize in the University of Malaya as a permanent reminder of this very successful Congress and the events which it honoured. Since the Congress was originally conceived to pay public tribute to the works of Alfred Russel Wallace in Malaysia, it is fitting that this should be known as the 'Wallace Prize'. A few copies of the abstracts of papers and of the programme are available (3*s*. and 2*s*., respectively, including postage).

The scientific papers will be published in full in book form. Applications for the abstracts and programme and advance orders for the scientific papers should be sent to Prof. R. D. Purchon, Department of Zoology, University of Malaya.

R. D. PURCHON

THE HAFFKINE INSTITUTE, BOMBAY

DIAMOND JUBILEE

ON January 10 the Haffkine Institute in Bombay celebrated sixty years of service in medical research. At the opening ceremony, which was attended by scientists from India and from other countries, the President of the Republic of India, Dr. Rajendra Prasad, said that Dr. W. M. W. Haffkine, founder of the Institute, had built up a tradition which the modern scientific world could best honour by emulation. It might have been a coincidence that a scientist born in Russia and trained in France happened to be in India, when he was assigned the urgent task of preventing plague from taking a heavy toll of lives; but, the President continued, it served to illustrate that scientific advance of all types called for international collaboration. The Bombay Health Minister, welcoming the delegates, announced that the Government of India had given Rs. 300,000 for the expansion of the Institute and that the Government of Bombay had decided to create a special fund for its development.

Waldemar Mordecai Wolff Haffkine was born of Jewish parents at Odessa on March 15, 1860. He obtained his doctorate in science at the University of Odessa in 1884 and, after working with the physiologist, Moritz Schiff, at Geneva, went to the Pasteur Institute at Paris in 1889 as *préparateur*. Pasteur had introduced vaccine treatment for fowl cholera, and Haffkine in 1892 developed the first successful vaccine against human cholera. Through the influence of Lord Dufferin, British Ambassador at Paris and former Viceroy of India, Haffkine was sent to Calcutta in 1893. The results of his anti-cholera inoculations were so encouraging that the Government of India in October 1896 transferred him to Bombay, where plague had broken out. Haffkine began work at the Petit Laboratory of Grant Medical College; his accommodation consisted of one room and a corridor, and his staff numbered one clerk and three peons, none of whom knew anything of bacteriological methods and had to be trained by him. He succeeded in preparing a prophylactic plague vaccine from pure cultures, which he proved to be harmless on his own person. Its first trial on a plague-stricken community was made in the Bombay House of Correction at Byculla in January 1897. Of 172 untreated prisoners, twelve developed the disease and six died; of 147 inoculated persons, two contracted plague, but none died. During the season at which the plague was prevalent, up to October 1897, 8,142 inhabitants of Bombay applied for inoculation. In April 1897 Haffkine moved his laboratory to a house on Malabar Hill, and in November made another move to premises in Nepean Sea Road, provided by the municipality.

In the following February the Aga Khan placed at his disposal a large house, Khushru Lodge, in Nesbit Lane, Mazagaon. When orders for the prophylactic vaccine began to pour in from all parts of the world, the laboratory became an Imperial concern, and larger premises had to be found at the Old Government House, Parel. The new laboratory was formally opened by the Governor of Bombay, Lord Sandhurst, on August 10, 1899, when Major W. B. Bannerman gave an account of the prophylactic and its action. Three years later Haffkine was appointed director of the Biological Laboratory at Calcutta. He left India in 1916 and lived in retirement at Boulogne-sur-Seine and at Lausanne, where he died on October 26, 1930, aged seventy. A charming, kindly and enthusiastic personality, an accomplished linguist, and a 'bacteriological wizard', Haffkine never married. He was created C.I.E. in 1917.

In 1925 the Government of Bombay decided to call the bacteriological laboratory at Parel 'The Haffkine Institute' to commemorate the name of its founder (*Nature*, 116, 551; 1925).

To-day, this Institute is the largest research institution of its kind not only in India but also in the East. It has a technical staff of more than one hundred scientists and a subordinate staff of more than five hundred workers, supervized by eight assistant directors and one director, Dr. H. I. Jhala. Its functions are medical research, training of research workers, supply of vital biologicals and diagnostic aids. The vaccine department collaborates with the Plague Committee of the Indian Council of Medical Research in research on plague, and with the World Health Organization in standardization of cholera vaccine. The department of virus diseases acts as a laboratory for an influenza centre in India, in the network of World Health Organization laboratories attached to the World Influenza Centre, London. The Institute is affiliated to the University of Bombay for degrees of M.Sc. and Ph.D. in microbiology, biochemistry, organic chemistry, pharmacology, pathology, bacteriology and zoology. W. R. Bett

UNIVERSITY OF OXFORD TANGANYIKA EXPEDITION

A PARTY from the University of Oxford, with the support of the Government of Tanganyika, made a preliminary scientific survey of the Kungwe-Mahali Mountains on the eastern shore of Lake Tanganyika (longitude 30° E., latitude 6° S.) during July–October 1958.

A herbarium collection was made of the plants of the southern two-thirds of the peninsula by J. G. B. Newbould, T. G. Jefford and B. E. Juniper, of the Botany School, Oxford. This is the first major collection from the area. The material will be assembled and identified at the Royal Botanic Gardens, Kew, for inclusion in the Flora of East Africa. In addition, live orchids were collected and are now in the orchid houses at Kew. Colour photographs were taken of the principal vegetation zones of the area and of many species of flowering plants.

H. F. Lamprey and A. J. Mence, of the Game Department, Tanganyika, and S. Ulfstrand, of the Zoologiska Institution, Lund, made a collection of birds and small mammals. This includes 305 birds, comprising about 135 species. Another 100 species were identified by sight. Among the birds collected were *Campethera taeniolaema* and *Psalidoprocne chalybea*. These records extend considerably the known ranges of these birds. One specimen, a woodpecker of the genus *Campethera*, with affinities to *C. abingoni*, fits no described species and still remains to be identified.

Among the small mammals, which are at present being examined at the British Museum, is the second specimen from Tanganyika of the ground squirrel genus *Protoxerus*.

A survey was also made of the isolated chimpanzee population. When further information is available about the flora, particularly of the forest species, further conclusions may be drawn about the affinities this region has with West Africa. These affinities are already apparent to a certain extent in the records of chimpanzees and *Protoxerus*.

T. E. Stevens completed a geological survey of the south, centre and west of the Mahali Range. Several interesting geomorphological features were observed and a collection of rock specimens was made which will be examined in the Department of Geology, Oxford.

P. L. Simkin, of the University of Oxford, and A. Roggenkämper, of the University of Bonn, made some preliminary anthropological observations among the Waholoholo of the Mahali Mountains. A census was made of the population of some of the villages south of Mount Kungwe. Studies were also made of social habits and ceremonies, witchcraft and beliefs, with particular reference to the worship of the god Kungwe.

More than 7,000 ft. of 16-mm. ciné film was exposed during the field work of the expedition and on aspects of the village life of the Waholoholo. Songs, musical instruments, drumming, dances and conversation of the Waholoholo, bird song and animal noises were recorded on tape by A. Roggenkämper.

A second expedition to the same area with a different emphasis is being planned for 1959. It will include a zoologist to work on the freshwater fauna and another zoologist, three geologists, one botanist, and probably a medical man and a soil scientist.

B. E. JUNIPER

RADIO TRANSMISSION BY WAVE-GUIDE

THE continually increasing demand for radio frequencies for new and expanding services makes it necessary to review periodically the possibilities of any alternatives to free-space radio circuits. The installation of the trans-Atlantic coaxial cable carrying a large number of telephone circuits has been an outstanding success; and wide-band coaxial cables are in use as alternatives to radio links for conveying television signals over shorter distances. But coaxial cables, using the materials and techniques at present available, are limited to an upper working frequency of about 25 Mc./s., beyond which the attenuation and phase characteristics become unacceptable. With the development in recent years of the technique of generation and reception of ever higher radio-frequencies, corresponding to wave-lengths down to a few millimetres, the hollow tubular wave-guide has become a serious competitor of the coaxial cable. It was therefore very timely that a well-attended convention on "Long-distance Transmission by Wave-guide" was held on January 29 and 30 by the Radio and Telecommunication Section of the Institution of Electrical Engineers.

At the opening session of the convention, Prof. H. E. M. Barlow gave a most interesting and lucid introductory survey of the present technique of guiding radio waves along the outside surface of a single wire and along the inside of a hollow tube. His presentation included demonstrations of the configuration of the electric field both along a wire and inside a tube using a neon gas discharge, of the effect of a dielectric coating on a wire to counteract the radiation from it, and of the manner in which transducers can be arranged to connect cables to wave-guides. One of the great advantages of a copper tubular guide, about 2 in. in diameter, is that its attenuation for circular electric modes decreases with increase of frequency of the radio waves. For example, at a frequency of 40 Gc./s., corresponding to a wave-length of about 7 mm., the attenuation of the guide is about 6 decibels per mile.

At the remaining five sessions of the Convention more than thirty papers were presented; many of these were of a detailed technical nature and they illustrated the advance which is being made in this field in Great Britain and other countries. Some of these papers dealt with both theoretical and practical aspects of avoiding spurious modes of transmission of radio waves in the tube, and the need to discriminate carefully in the conduct of measurements on the characteristics of the guide. Special microwave equipment is being developed to generate the very short waves involved, and particularly to couple the source to the guide, so that waves of the desired mode may be launched with the minimum loss of energy. The last session was devoted to a discussion of the practical possibilities of wave-guides for long-distance transmission, including the economic aspects of such communication systems. The speakers here stressed the fact that not only must such systems have a high degree of stability, but that, so far as possible, they must also be compatible with existing signalling networks as regards facilities for the insertion and extraction of signals at terminals and intermediate points.

On January 31, demonstrations were given of a variety of experiments using millimetre waves associated with tubular wave-guides in the Electrical Engineering Department of University College, London, and at the premises of Standard Telecommunication Laboratories, Ltd., at Watton-at-Stone, near Stevenage.

The text of all papers presented at the convention, together with the associated discussion, will be published in a Supplement to Part *B* of the *Proceedings of the Institution of Electrical Engineers*.

R. L. SMITH-ROSE

HILL FARMING RESEARCH ORGANIZATION

REPORT FOR 1954–58

THE scientific investigation of the problems of hill farming remained largely sporadic and unco-ordinated until it became recognized that this sector of the British agricultural industry is a distinctive form of land-use, based on complex and varying interactions of plant and animal communities which in themselves merit concerted programmes of research to define them more clearly and to attack their major problems. This concept provides the background to the establishment in 1954 of a central research organization and to its objectives and activities; these are clearly and succinctly described in the first report of the Hill Farming Research Organization*.

The extensive distribution of the hill farming areas in Great Britain, and the great ranges in environmental conditions and husbandry systems offer wide scope for study; three factors have tended to restrict,

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* Hill Farming Research Organization. First Report, 1954–58. Pp. 88. (Edinburgh: Hill Farming Research Organization, 1958.)

as yet, development of the Organization's work. In the first place, any investigations of such a complex must be on a long-term basis; a small, though full-time, staff can only encompass narrow segments of the field, and in some four years their work can only be preliminary. Secondly, the work must be biased towards 'field' studies, with the niceties and precision of replicated experimentation largely sacrificed. Thirdly, the Organization's three research stations, to the resources of which much of the programme has had to be geared, were inherited from an earlier régime of separate interests in hill farming problems as presented in the areas of the three Scottish agricultural colleges.

At Glensaugh, in Kincardineshire, the basic Blackface sheep stock, on predominantly heather vegetation, is managed according to the custom of the north-eastern counties of Scotland; studies on the dentition and on winter feeding of sheep are in progress, as well as on different breeds and crosses of beef cattle in relation to prolificacy and growth of calves. Lephinmore, in the Cowal peninsula of Argyllshire, provides a varied hill ground in an area of high rainfall, relict from afforestation of plantable land, and thus having peculiar management problems for its Blackface sheep stocks. Sourhope, in Roxburghshire, is the main station for work on Cheviot sheep under conditions reasonably typical of the Cheviot hill areas; investigations on mixed grazing with cattle and sheep had begun in 1951, and others on controlled grazing and on the treatment of cobalt deficiency have since been added.

Animal studies are in two main groups, related respectively to breeding and nutrition. In the former, comparisons of breed and strain are being made with the Blackface and Cheviot breed types, while in respect of the latter, the principal emphasis has been on problems of the nutritional status of hill sheep in winter; various methods and forms of supplementary winter feeding are being examined, responses in the mortality and growth of lambs observed, and differences in feeding habits noted. Particular attention is being given to the plane of nutrition, and methods of 'wintering', of flock replacements during their first winter.

The botanical work is described in more detail. Studies on management involve the effects of burning, drainage, surface seeding and cultivations, sod-seeding, heather grazing, fertilizer treatments, and bracken control. The great significance of the ecological aspects of the hill vegetation influences the investigations on plant communities and their species components and ecotypes; investigations in these fields are being conducted in a wider range of localities and environments beyond those presented in the Organization's own farms. Exploratory studies on the sheep grazing behaviour and preferences in relation to plant communities are being made at Sourhope.

A list of publications is given, and almost by way of appendixes, there are three occasional papers comprising reports on surveys of management systems in Blackface sheep in the north-east of Scotland (with special reference to the incidence of breakdown of incisor teeth with age), and of Border Cheviot sheep, and a short note on the effects of August treatments of a pasture sward on its subsequent yields in autumn, winter and spring.

J. E. NICHOLS

ULTRA-VIOLET CARCINOGENESIS IN ALBINO AND PIGMENTED MICE RECEIVING FUROCOUMARINS: PSORALEN AND 8-METHOXYPSORALEN

By M. A. PATHAK, PROFS. F. DANIELS, jun., C. E. HOPKINS and T. B. FITZPATRICK

University of Oregon Medical School, Portland, Oregon

EPIDEMIOLOGICAL evidence clearly implicates solar radiation as a factor in the induction of human skin cancer[1,2]. A factor which appears to protect man from carcinoma induced by exposure to solar radiation is melanin pigment, the darkly pigmented peoples having a markedly reduced incidence of carcinoma of the exposed areas[2–5]. The generalized human albino living in the tropics almost invariably develops squamous and basal cell carcinoma of the exposed surfaces[4]. Similarly, the fair-skinned Caucasians who easily become sunburnt and have a tendency for freckling have a higher incidence of carcinoma of the exposed areas than persons who tan readily[6,7]. The carcinogenicity of ultra-violet irradiation in albino mice has been established by many investigators[3,8–12] and has therefore provided an excellent experimental tool for studying the process of skin carcinogenesis.

Naturally occurring furocoumarins (psoralen, 8-methoxypsoralen or methoxsalen) have recently been used for augmenting pigmentation of human skin following irradiation with long-wave ultra-violet light. This raised the question whether these photoactive compounds might alter the incidence of ultra-violet carcinogenesis. O'Neal and Griffin[13] initiated studies on 8-methoxypsoralen and its effect on ultra-violet carcinogenesis in albino mice. Their initial report indicated that the final incidence of ear tumours induced by ultra-violet irradiation ($15 \cdot 2$ to $17 \cdot 5 \times 10^{8}$ ergs/cm.^{2} of short and medium range up to 3200 A.) in mice receiving 8-methoxypsoralen orally (0·5 gm./kgm. diet) was considerably less than that of control mice, evidence suggesting that this photoactive agent had a 'protective' effect against ultra-violet carcinogenesis. The extent of protection afforded by this compound appeared to be proportional to its concentration in diet up to an optimal level of 0·5 gm./kgm. diet. They found, however, in the same experiment that intraperitoneal administration of 8-methoxypsoralen (0·4 mgm./mouse/day) appeared to increase tumour incidence. Whether the discrepant effects of oral and intraperitoneal administration were related to a difference in the dose or in the route of administration was not resolved.

The present study was undertaken to determine: (*a*) whether 8-methoxypsoralen and psoralen (furo-2′,3′: 6,7-coumarin) when given in oral form protected or otherwise affected the ultra-violet carcinogenesis in albino and pigmented mice; (*b*) if the findings of O'Neal and Griffin[13] could be explained on the basis of differences between the oral and intraperitoneal route of administration; (*c*) the effect of a second furocoumarin, psoralen, as compared to 8-methoxypsoralen (Fowlks *et al.*[14], Pathak and Fitzpatrick[15] and other investigators[16] have reported psoralen to be the most potent photoactive naturally occurring furocoumarin); (*d*) the role of melanin pigment in the skin in ultra-violet carcinogenesis.

Three strains of female mice were used: Swiss strain albino mice, strain *C57BL/6* with black ears, black eyes and hair, and a deep brown strain *C57Br/cd* (Jackson Memorial Laboratory, Bar Harbor, Maine). An ultra-violet irradiation chamber was constructed with two *UA*3 General Electric 'Uviarc' lamps mounted adjacently in aluminium reflectors[13]. The mice were exposed to the total ultra-violet spectrum (mostly short and middle ultra-violet at a distance of 50 cm.). Intensity of illumination under the lamp in a 2 sq. ft. area was determined every 4 weeks by photolysis of uranyl oxalate solutions according to the method of Leighton and Forbes[17]. Quantum yield for the entire spectrum was taken as 0·57 φ. To prevent huddling or movements of mice during irradiation special cages holding each mouse in a separate compartment were used[10,12,13].

Mice 8–10 weeks old with comparable average weight within each strain were randomly divided into cage groups of 20 each. Twenty-eight groups were used: twelve in the albino series, eight in *C57BL/6* strain and eight in *C57Br/cd* strain. Each group received ultra-violet irradiation for six days a week at the rate of $2{\cdot}9 \times 10^{4}$ ergs/cm.^{2}/sec. Total ultra-violet irradiation received by each group was $14{\cdot}8 \times 10^{8}$ ergs/cm.^{2} delivered in 850 min.[12]. Irradiation was discontinued after 110 days for albino mice and after 120 days for pigmented mice, following which the observations for tumour incidence were continued for a total of 260 days. Changes in temperature during irradiation were minimized by slow circulation of air from a revolving electric fan. To minimize the possibility of photo-reactivation the animals were housed in a windowless, dark room.

Because the findings of O'Neal and Griffin[13] might be explained by a biphasic response with protection from carcinogenesis by the small doses of 8-methoxypsoralen received in the dietary group, and potentiation by the large doses given in the intraperitoneal group, only oral doses were used in this study. Administration of drugs was carried out by addition of 8-methoxypsoralen or psoralen in a concentration of 0·5 gm. per kgm. of powdered 'Purina Laboratory Chow', which was mixed in a revolving ball mill for 12 hr. Each day's food intake was recorded for each group receiving drugs in the diet. A second method consisted of measured quantities of drug given individually to each mouse by oral feeding from a tuberculin syringe with an attached 18 gauge, semi-curved metal tube 1 in. long. It was possible by slowly inserting the bent tube into the mouth to administer 0·05 ml. suspension of either psoralen or 8-methoxypsoralen prepared in 0·5 per cent gum acacia solution. Wood's light examination of the mice after feeding determined that no spillage of fluorescent compounds had occurred around the mouth. Preliminary tests had indicated that, with oral feeding, the furocoumarins developed their highest concentration in the blood in 1¼ hr. Ultra-violet irradiation was therefore given at this time-interval following drug administration. The dose schedule, as shown below, included the range of levels used by O'Neal and Griffin on intraperitoneal dose and also 0·01 mgm., the equivalent of a 20–30 mgm. dose of the drugs in man. Administration of drug was discontinued after 120 days. The experimental schedule is given in Table 1.

Table 1. EXPERIMENTAL GROUPS AND DOSE SCHEDULE

Dose	Mouse strains and group numbers		
	Swiss Albino	Brown *C57Br/cd*	Black *C57BL/6*
Controls (no drug)	1, 2	13	21
8-Methoxypsoralen mgm./mouse/day			
Oral—0·01	3	14	22
,, 0·04	4	15	23
,, 0·16	5		
,, 0·64	6	16	24
Dietary 1·7	7	17	25
Psoralen mgm./mouse/day			
Oral—0·01	8	18	26
,, 0·04	9		
,, 0·16	10		
,, 0·64	11	19	27
Dietary 1·7	12	20	28

Each mouse was tagged for individual identification in the observation of effects of irradiation. The mice were examined separately by three observers (M. P., T. B. F. and F. D.) every ten days. The last two observers did not know the identity of the groups until the completion of the experiment. A five-point grading system was used: normal ear, 0; inflammatory response without nodules, 1; suspicious nodules, 2; definite nodule suggestive of cancer, 3; definite tumour, 4. Right and left ear were recorded separately for each mouse. A mouse graded 3 or 4 on either ear by at least two observers was recorded as having a tumour. The analysis is based on the number of mice having tumours and not the total number of tumours. Mice dying after 120 days of irradiation with grades 0, 1 and 2 were considered to have no tumour. The final tumour incidence is expressed as a percentage of the initial number of mice in each group.

Within a week after the beginning of irradiation both the albino and the pigmented mice showed erythema and scaling on the ears. In about three weeks the scale had come loose and ears showed thickening. Both types of pigmented mice showed increased pigmentation of the ears and tail region. This pigmentation was greater in the mice receiving the drugs. Mice receiving 8-methoxypsoralen or psoralen at the 0·64-mgm. level had severe erythema of the ears, nose and face regions. These regions were sufficiently burned to be followed by scar formation, loss of hair, and thickening of the ears. The control animals (groups Nos. 1, 2, 13 and 21) showed less-severe ultra-violet burns. Groups receiving 0·01, 0·04, 0·16 mgm. of 8-methoxypsoralen or psoralen and the dietary groups showed no appreciable damage of irradiated regions. The groups receiving 0·64 mgm. in the pigmented mice showed less damage than the albino groups. During the first 45–100

Table 2. INCIDENCE OF EAR TUMOUR IN THREE STRAINS OF MICE EXPOSED TO ULTRA-VIOLET IRRADIATION AFTER ADMINISTRATION OF FUROCOUMARINS (PER CENT)

Strain	No drug		8-Methoxypsoralen (mgm./mouse/day)					Psoralen (mgm./mouse/day)				
	Controls		Oral administration (mgm.)				Dietary	Oral administration (mgm.)				Dietary
			0·01	0·04	0·16	0·64	1·7 mgm.	0·01	0·04	0·16	0·64	1·7 mgm.
Albino mice Swiss strain	60	70	50	45	40	45	65	55	65	40	60	60
Brown pigmented *C57Br/cd*	15		10	0		0	25	0			5	0
Black pigmented *C57BL/6*	20		5	5		10	15	0			15	5

Least wholly significant percentage point difference (5 per cent level) = 35 per cent; least wholly significant percentage point difference (1 per cent level) = 40 per cent.

Criterion for comparing any two cage outcomes: P_1-P_2 is significant at $P = 0{\cdot}05$ level if $P_1-P_2 \geqslant 1/2N + \frac{1{\cdot}96}{\sqrt{N}}\sqrt{P_1+P_2-1/2P_1^2-P_1P_2-1/2P_2^2}$, which reduces, when $N = 20$, to $0{\cdot}025 + 0{\cdot}451\sqrt{P_1+P_2-1/2P_1^2-P_1P_2-1/2P_2^2}$

days, the observers could not differentiate the control groups from the groups receiving 0·01, 0·04, 0·16 mgm. of drugs.. Cataracts developed in many of the animals, in both the control and dietary groups. The pigmented as well as the albino mice developed cataracts. Changes in the eyes were slightly more severe in all the groups on high doses (0·16–0·64 mgm.) of the two drugs. In the albino series, about 5–10 per cent of the mice had tumours of the eyelids. There were no tumours of the eyelid in pigmented groups. The death-rate up to the end of the irradiation period (120 days) was less than 10 per cent in all 28 groups.

The final tumour incidences are summarized in Table 2. In contrast to the findings of O'Neal and Griffin[13], there was no protecting or stimulating effect of 8-methoxypsoralen or psoralen on ultra-violet carcinogenesis in the albino mice. The incidence of tumours in the two pigmented strains of mice was much less than in the albino strain. Five of the groups showed no tumour, four groups had only 5 per cent tumours, two groups had 10 per cent; the rest of the five groups had tumour incidences ranging from 15 to 25 per cent.

The albino mice appeared to develop tumours earlier than the brown or black mice. After starting the ultra-violet irradiation, the control groups in the albino series showed first tumour induction at the end of 90 days; the control groups in both of the pigmented mice strains showed first tumour induction after 166 days. In the albino mice, eight out of the ten groups receiving psoralen or 8-methoxypsoralen, either orally or through the diet, developed tumours after 90–116 days. As compared to albino mice, the rate of tumour induction in both these pigmented mice strains receiving psoralen or 8-methoxypsoralen was very slow. In six pigmented groups, the first tumour induction time was around 147 days. In the rest of the other five groups which showed the development of tumours the induction time was greater than 166 days. The significant variable differentiating the albino and the pigmented strains appears to be melanin pigment. Presence of melanin pigment possibly retards tumour induction, and affords an appreciable protection against ultra-violet carcinogenesis.

There was no effect on the total tumour incidence of different dose-levels of the drug. There was neither potentiation nor protection from ultra-violet carcinogenesis. The albino mice groups receiving the highest dose of psoralen (0·64 mgm.), however, showed a shortened induction time, beginning at only 56 days. This acceleration of cancer induction is not surprising in view of the experimental damage to the animals on this high dose of 0·64 mgm. psoralen. It is of interest that the final tumour incidence did not increase in these animals. As mentioned previously, psoralen has been shown in experiments on humans to have a more potent photoactive effect than 8-methoxypsoralen[15]. This effect of psoralen in the present study was observed in only one albino group receiving the highest dose of 0·64 mgm. It accelerated the rate of tumour induction but not the total incidence. Psoralen and 8-methoxypsoralen otherwise showed similar responses and did not affect the final incidence of ultra-violet carcinogenesis in either albino or pigmented mice.

From these experiments it is concluded that the findings of O'Neal and Griffin[13] indicating that 8-methoxypsoralen provided protection against ultra-violet carcinogenesis are not confirmed. Under our conditions no potentiation of carcinogenesis was demonstrated by 8-methoxypsoralen or psoralen in dose-levels ranging from 0·01 to 0·16 mgm./mouse/day. Dietary feeding of psoralen or 8-methoxypsoralen (0·5 mgm./kgm. diet) did not reveal any protective effect against ultra-violet carcinogenesis. Some factor, possibly the melanin pigment in brown and black pigmented mice, appeared to protect the pigmented mice appreciably against ultra-violet carcinogenesis.

We are indebted to the Paul B. Elder Co., Bryan, Ohio, and Sandoz, Ltd., Basle, Switzerland, for the supply of the two compounds, and to Dr. W. L. Fowlks for his interest and guidance.

This investigation was supported by Public Health Service grant number *C2837 (C)*.

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MUTAGENIC ACTIVITY OF THE ALKALOID HELIOTRINE IN *DROSOPHILA*

By Dr. A. M. CLARK
Department of Zoology, University of Melbourne

NATURALLY occurring chemical mutagens of plants are of considerable general interest because of the possibility that they make an appreciable contribution to the apparent spontaneous mutation-rate, both of the plants in which they occur and of any phytophagous animal species which may be sensitive towards them. In some cases, these mutagens might assume practical importance if they are active following ingestion by agricultural livestock. A number of the pyrollizidine alkaloids from various plants (*Heliotropium*, *Senecio*, *Crotalaria*) have been shown to possess considerable biological activity[1-3]. It therefore seemed worth while to test them for mutagenic properties. This article is intended to direct attention to the mutagenic activity of heliotrine, an alkaloid from *Heliotropium europaeum*[4].

To test the mutagenic activity of heliotrine in *D. melanogaster*, the Muller-5 technique for sex-linked recessive lethals was used. Following an injection of 0·08 µl. of a solution of heliotrine in 0·7 per cent sodium chloride, Canton-*S* males were mated individually to three *Basc* females, fresh females being provided at intervals of 72 hr. Cultures were maintained at 25° C. In the Canton-*S* stock in use in this laboratory, the spontaneous incidence of sex-linked recessive lethals is about 0·1 per cent for sperm produced during the first few days of adult life. All suspected lethals were confirmed in the F_3 and many have been kept in culture for further cytogenetic analysis.

Table 1. Production of Sex-linked Lethals following Injection into Adult Males of 0·08 µl. of a 0·3 per cent Solution of Heliotrine in Saline
Brood interval of 72 hr.

	Brood 1	2	3	4	5
Chromosomes tested	558	563	233	116	102
Lethals	31	10	17	6	3
Per cent lethals	5·6	1·8	7·3	5·2	2·9

The existence of perhaps two sensitive periods is suggested by the results in Table 1, representing the distribution of lethals over five successive broods following the injection in the males of 0·3 per cent heliotrine (approximately 0·01 *M*). The relatively small number of chromosomes tested from the last three broods is a reflexion of the partial sterilizing action of heliotrine in *Drosophila*. In fact, if the concentration of heliotrine exceeds about 0·5 per cent, the injection of 0·08 µl. of the solution renders it possible to obtain only the first two broods. The mutagen seems to block the maturation of immature germ cells, so that as soon as the available spermatozoa and spermatids have been utilized, the males are no longer capable of breeding, although they may remain alive and active for as long as three weeks after treatment. Since fertility is not regained within this period, the cell damage caused by the alkaloid is presumably quite irreversible.

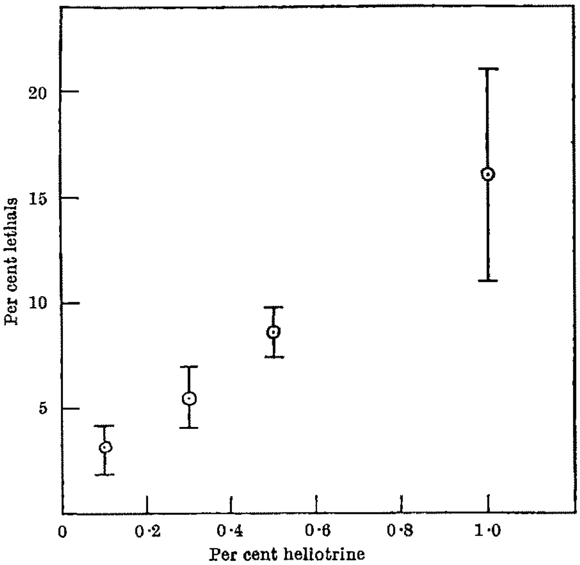

Fig. 1. Percentage of sex-linked recessive lethals (with 95 per cent confidence limits) at different heliotrine concentrations. First brood only

If the concentration of heliotrine is in excess of 1 per cent, then only a single brood is obtained, in which the incidence of lethals may be higher than 30 per cent. This single brood is often obtained as a result of copulation occurring within 1 hr. of treatment, indicating that the heliotrine does not in itself retard the mating behaviour of the males. Failure to obtain a second brood suggests some degree of destruction of spermatids or, alternatively, an inhibition of spermogenesis. By using alkaloid concentrations of less than 0·5 per cent several broods can be obtained readily, and the mutagenic effect is then found to extend back to pregonial cells. Clustering of lethals is common in these later broods.

Fig. 1 shows the results of an experiment to determine the relation of the dose response for the first brood only (spermatozoa mature at the time of treatment), using a ten-fold range in heliotrine concentration. Under the conditions of test, the relation appears to be linear. At the highest concentration used, however, the sampling error is large owing to the reduced number of offspring that can be obtained. Some deviation from simple linearity might be expected at the higher dose-levels in the light of observations (to be published elsewhere) on the ability of heliotrine to induce large structural rearrangements in *Drosophila*.

Bull, Dick, Keast and Edgar[3] have made an extensive investigation of heliotrope poisoning in sheep, and have shown that consumption of the plant results in severe liver damage. Bull[5] has further shown that heliotrine can produce similar damage to the liver of laboratory rats, while Schoental and Magee[3] have demonstrated the carcinogenic properties of the related alkaloid lasiocarpine.

Crowley and Culvenor[6] have found that different samples of *Heliotropium europaeum* may show considerable variability with respect to alkaloid content; but in none of their assays was there any indication that the content ever falls to a level at which hepatotoxic effects would not be expected to ensue following extensive feeding on the plant by sheep. However, even if the alkaloid-levels are low or if feeding is relatively restricted, there would now appear to be the possibility that livestock failing to develop toxic symptoms may nevertheless have suffered some degree of genetic deterioration.

The powerful mutagenic activity of heliotrine raises the interesting question of whether *Heliotropium* itself is sensitive towards this chemical. No information is yet available on this point. It may be recalled that although early work[7] seemed to suggest that *Colchicum autumnale* is resistant to the action of colchicine, later investigators have shown that this plant is in fact sensitive towards its own mitotic poison[8,9], and Takenaka[10,11] has reported disturbances of the *C*-mitotic type in root tips and pollen mother cells of *Colchicum* plants living under natural conditions. Nevertheless, it seems to be the case that rather high concentrations of the drug are necessary for typical colchicine effects to be produced. High-threshold concentrations may also characterize any mutagenic effects exerted by heliotrine upon the chromosomes of *Heliotropium*. It is, of course, possible that the mutagenic action is a property not of heliotrine itself but of some degradation product resulting from the enzymatic splitting of the alkaloid. In the intact plant, the enzyme may be lacking or it may be spatially separated by some means from the substrate.

A simple change which heliotrine might undergo after injection into *Drosophila* would be the splitting of the ester linkage, releasing heliotridine and heliotric acid. To test this possibility, hæmolymph and tissue homogenates were tested for esterase activity capable of splitting the alkaloid, but without success. In any event, heliotric acid is only feebly mutagenic when injected into *Drosophila*, while heliotridine is quite inactive, suggesting that the strong mutagenic property of heliotrine itself is probably a property of the molecule as a whole rather than of some degradation product.

My thanks are due to Prof. G. S. Christie of the Pathology Department of this University for first directing my attention to heliotrine as a possible mutagen, and to Dr. C. C. J. Culvenor of the Commonwealth Scientific and Industrial Research Organization, Division of Industrial Chemistry, for providing samples of various pyrollizidine alkaloids.

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COSMIC DUST IN THE ATMOSPHERE

By DR. D. W. PARKIN and W. HUNTER

Department of Physics and Mathematics, Liverpool College of Technology

THE extensive work of Prof. H. Pettersson and his colleagues[1] and the analytical work of Smales *et al.*[2] have established that certain magnetic spherules (about 50μ diameter) obtained from deep-sea sediments are extra-terrestrial. Magnetic spherules, similar in size and appearance to these 'cosmic spherules', have been collected by several observers directly from the air. Buddhue[3] showed that many such spherules could be picked up, daily, by a greased slide. However, vast numbers of these particles appear in chimney fly-ash and some doubt exists concerning the origin of spherules collected, even in isolated places.

During August 1957, a plastic bowl of filtered water, area 1/6 sq. m., was exposed at the top of the lighthouse on Bardsey Island (North Wales), in the hope of detecting fine dust from the Perseid meteor shower. About fifty black or silvery magnetic balls of around 10μ diameter were collected daily. This number varied according to weather conditions, strong winds and no rain increasing the daily catch considerably. Towards the end of this examination, attention was attracted to certain metallic-looking flakes ; and it was established that some of these were metallic iron, copper being immediately deposited from a surrounding bead of copper sulphate solution. X-ray examination of one of these particles showed it to be fine-grained polycrystalline iron.

About a gallon of melt-water, obtained by Mr. L. K. Coachman (Department of Oceanography, University of Washington) from the wall of a crevasse in West Greenland, yielded 19 magnetic spherules ranging in diameter from 5μ to 35μ (mainly about 20μ in diameter). In addition to many black and vari-coloured magnetic fragments, four flakes of metallic iron similar to the Bardsey specimens were found. One of these was a remarkably straight needle-shaped object of square-like cross-section 240μ long and 20μ wide.

On occasions during the summer months, aircraft of the Meteorological Research Flight have been collecting samples of dust over southern England at 10,000 ft., while flying at a speed of about 200 m.p.h. A slotted 'Perspex' slide of effective collecting area 10 sq. cm. was thinly coated with gelatine. Each slide, held in an aluminium frame, was exposed from the side of the fuselage, for exactly 30 min. The results of flights carried out on August 11 and 20, 1958, are of particular interest. Three slides were exposed during each flight.

'Terrestrial-looking' sand particles (generally flakes) as large as 150μ were found, but the presence of only a few spherules was surprising. On average, each slide picked up two or three sand grains of about 100μ diameter, a dozen around 50μ and many more in the smaller size-ranges. Only one or two opaque spherules (10μ–20μ) were observed. Among the fragmentary opaque material, which followed a similar size-distribution, several interesting metallic-bearing particles were found.

On a slide exposed during August 20, a large silvery flake ($200\mu \times 100\mu \times 20\mu$) was found firmly embedded in the gelatine layer. In parts it was covered with small grey translucent balls which appeared to sprout from the surface, and the particle appeared to be a loosely aggregated structure of small grains. The addition of copper sulphate quickly turned it a matt black-bronze, with here and there bright specks of copper. By softening the gelatine it was possible to lever out a large section, and Fig. 1 shows the impact region on the gelatine, together with a few pieces that remained in position (The tiny specks around the main area are chippings made by a glass fibre.) The extracted section was to be examined by X-rays, but during manipulation in a pool of glue it fell apart. On the same slide another flake, about 50μ in size, embedded like a knife blade in the gelatine, reacted immediately to the copper sulphate test.

The long needle-shaped particle (Fig. 2) is typical of another kind of fragment. This at first did not react to copper sulphate, but later dendritic copper grew out from certain spots which are presumably the sites of cracks in a surface oxide layer. Although most attention was paid to the large fragments, several of the smaller ones deposited copper, particularly after their surfaces had been damaged.

These oxide-coated particles must be similar to those described by Buddhue, who noticed that some of the fragments emitted tiny bubbles when the sample was under acid. He also detected chemically the presence of more iron after the sample had been crushed.

The possible extra-terrestrial nature of these metallic fragments must be seriously considered. On the average, each slide collected about one as large as 100μ, and since sand grains of this size-range occurred with only two or three times this frequency, it seems unlikely that the metallic particles could have been transported from ground-level to 10,000 ft. Industrial dust, collected over Liverpool, has been examined on many occasions, and although metallic iron fragments have been found they are located with the utmost difficulty. These fragments must be abraded from common iron as they are observed to rust quite readily.

The water-bowl technique was again adopted during August 1958. The bowl, of area 1/15 sq. m., was placed on a rocky prominence at the south-west tip of St. Agnes, Isles of Scilly. The winds were mainly in the south-west and since scarcely a day was free from rain the air was particularly clean. A thorough examination of the magnetic fraction in the water samples has now been completed, the non-magnetic portion being preserved for later inspection.

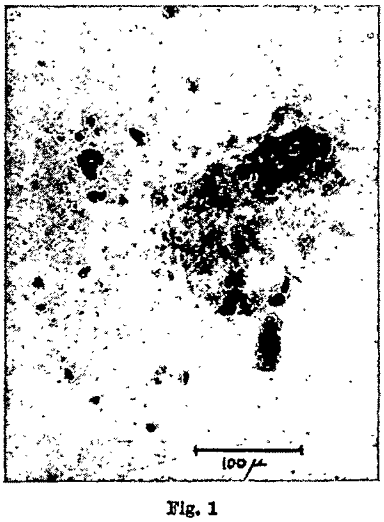

Fig. 1

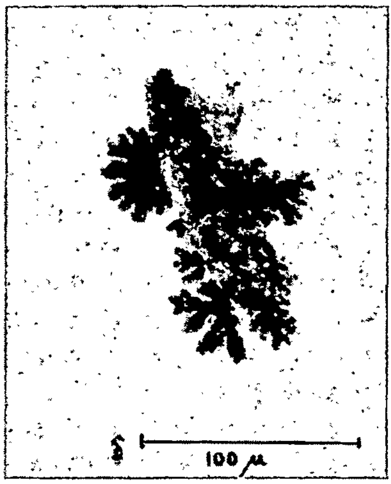

Fig. 2

On average, during a 48-hr. exposure, about a dozen black powdery aggregates varying in size around 40μ were recorded, together with two or three silvery flakes of the same size. For the whole month only 15 spherules about 10μ in diameter were collected; and only three silver flakes and one black flake were found to react to the copper sulphate test either immediately or after slight crushing. But a large (150μ) partly translucent aggregate picked up during the period August 11–13 was observed to deposit copper in a few spots on the surface and between the crystalline (or glassy) material, which appeared to be quite angular and slightly brown in colour. The presence of transparent material could be detected in the other metallic fragments particularly after they had been crushed.

Perhaps the strongest argument in favour of an extra-terrestrial origin is the detection of nickel in these particles. Due to a chemical method devised by Dr. J. P. Riley (Department of Oceanography, University of Liverpool), it has been possible to show a slight trace of nickel in the remnant in Fig. 1, and to be quite certain of its presence in the metal-bearing Scilly particles, using them all together.

The quantity of nickel is unknown, but from experience gained with particles of nickel-steel of given composition, it is fairly certain that in the Scilly particles the average nickel content is greater than 5 per cent.

Owing to the small quantity of material collected, it is impossible to be certain of a contribution from the Perseid shower. As emphasized by Öpik[4], it is likely that the large, and possibly continuous, fine dust deposit from the Zodiacal Cloud completely overwhelms any contribution from a meteor shower. Nevertheless, it is important to clarify this question, as Bowen[5] has given evidence of possible initiation of rainfall by meteor showers. If this extra-terrestrial material turns out to be primordial dust, a closer study of the metallic and stony material will be of great interest, as the particles should reflect conditions existing during their formation. Sampling the stratosphere would put much of this work on a surer footing.

We are indebted to Prof. K. F. Bowden of the Department of Oceanography, to Prof. W. S. Owen of the Department of Metallurgy, University of Liverpool, and to the Director General of the Meteorological Office, for facilities, and to Sir Edward Bullard of Cambridge, and Mr. B. C. Oddie of the Meteorological Office for much encouragement. We are especially grateful to Mr. W. G. Durbin, of the Meteorological Research Flight, for his participation in the experiment, and our thanks are due to several colleagues in the College of Technology, Liverpool.

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RESOLUTION OF CHLORPHENIRAMINE AND THE PHARMACOLOGICAL PROPERTIES OF ITS ISOMERS

By R. T. BRITTAIN, DR P. F. D'ARCY and DR. J. H. HUNT
Research Division, Allen and Hanburys, Ltd., Ware, Herts

CHLORPHENIRAMINE maleate ('Piriton', Allen and Hanburys, Ltd.) [3-(*p*-chlorophenyl)-3-(2'-pyridyl)-NN-dimethyl propylamine maleate][1,2] is a potent antihistamine[3]. We wish to report its resolution, and the physical constants, and the pharmacological properties of its optical isomers.

Chlorpheniramine proved somewhat difficult to resolve since it forms readily crystallizable salts with only a few acids. Initial attempts to form crystalline salts from fifteen optically active acids were not successful; however, after standing for one year, a solution of the di-*p*-toluoyl-(−)-tartrate[4,5] in aqueous ethanol deposited a few crystals. These were used to seed a freshly prepared solution giving (−)-chlorpheniramine-di-*p*-toluoyl-(−)-tartrate, which, after recrystallization to constant rotation, had melting point 135–136° C., $[\alpha]_D^{21} + 57\cdot4°$ (*c.* 1·1 in ethanol). This gave (−)-chlorpheniramine [$[\alpha]_D^{21\cdot5} - 31\cdot6°$ (*c.* 1·8 in ethanol)], which was converted to the hydrogen maleate [melting point 114–115° C., $[\alpha]_D^{27} - 23\cdot7°$ (*c.* 1·2 in water)].

The corresponding antipodes were obtained from the di-*p*-toluoyl-(+)-tartrate [melting point 135–36°, $[\alpha]_D^{20} - 57\cdot8°$ (*c.* 1·7 in ethanol)], which gave (+)-chlorpheniramine [$[\alpha]_D^{24} + 31\cdot6°$ (*c.* 1·3 in ethanol)], which was converted to the hydrogen maleate [melting point 114° C., $[\alpha]_D^{20} + 23\cdot1°$ (*c.* 2·0 in water)].

The anti-histamine activity of each isomer and the racemate was assessed by an *in vitro* method. The antagonistic effect of each drug on the contractions induced by histamine of the isolated ileum of the guinea pig was determined following the method of Schild[6]. The results expressed as pA_2 values (2 min. drug-tissue contact) are shown in Table 1.

The (+) isomer exhibited approximately twice the anti-histamine activity of the racemate, while the (−) isomer showed only about half the activity of the racemate. Further studies in which the pA_2 values of the drugs were assessed after 4 and 8 min. contact with the tissue showed that the duration of the anti-histamine action of neither isomer differed from that of the racemate.

Table 1

Compound	Anti-histamine activity pA_2 value (2 min. drug–tissue contact)
(+)-Chlorpheniramine maleate	8·47
(±)-Chlorpheniramine maleate	8·10
(−)-Chlorpheniramine maleate	7·81

Table 2

Compound	Acute intraperitoneal toxicity in mice $LD50$ mgm./kgm. ± standard error
(+)-Chlorpheniramine maleate	175·4 ± 9·7
(±)-Chlorpheniramine maleate	187·9 ± 6·7
(−)-Chlorpheniramine maleate	193·6 ± 7·5

The acute intraperitoneal toxicity of the racemate and isomers was studied in mice. Low doses of both racemate and isomers showed no observable reactions; however, high doses produced clonic convulsions followed by depression and death. Mortality was observed for seven days after administration of the drug. These results, expressed as the *LD*50 value in mgm./kgm. for each anti-histamine, are shown in Table 2. It is apparent that the acute toxicity of each isomer does not differ significantly from that of the other, nor from that of the racemate.

Sedation is one of the more common side-effects of many of the anti-histamine drugs in clinical use; it was therefore thought worth while to determine whether the racemate or either isomer caused any depression of the central nervous system. This was achieved by examining the compounds for their effect in modifying the narcotic activity of intraperitoneal injections of pentobarbitone sodium in mice. Narcotic activity was estimated using the rotating drum method of Collier, Hall and Fieller[7]. These results are summarized in Table 3, and show that neither of the isomers nor the racemate potentiates the action of the barbiturate. In fact, all three compounds, when injected intraperitoneally at a dosage of 100 mgm./kgm. at the same time as the pentobarbitone sodium, significantly reduce the duration of the narcosis without affecting the onset.

It has been well established that many antihistamines have a local anæsthetic action, a property that contributes to the beneficial effects of topical application of these agents in painful allergic or other dermatological conditions. In this study the local anæsthetic activity of the isomers and the racemate were determined in guinea pigs using the intradermal injection method of Somers and Edge[8]. Racemic chlorpheniramine maleate showed similar local anæsthetic activity to that of procaine hydro-

Table 3

Compound	No. of mice	Dose (mgm./kgm. intra-peritoneally)	Narcosis in mice				
			Pentobarb. sod. (mgm./kgm. intraperitoneally)	Onset (min. ± stand. error)	P	Duration (min. ± stand. error)	P
Saline	10	—	30	$3\cdot7 \pm 0\cdot5$	—	$16\cdot1 \pm 0\cdot9$	—
(+)-Chlorpheniramine maleate	10	100	30	$3\cdot7 \pm 0\cdot6$	$> 0\cdot9$	$12\cdot8 \pm 1\cdot0$	$< 0\cdot05$
(±)-Chlorpheniramine maleate	10	100	30	$4\cdot8 \pm 1\cdot0$	$> 0\cdot3$	$11\cdot6 \pm 1\cdot3$	$< 0\cdot01$
(−)-Chlorpheniramine maleate	10	100	30	$3\cdot8 \pm 0\cdot7$	$> 0\cdot8$	$11\cdot3 \pm 1\cdot6$	$< 0\cdot02$

chloride. The activity of the (−) isomer was approximately one and a half times, while the (+) isomer was only half that of the racemate.

It has been reported[9] that continued local use of anti-histamines may cause skin sensitization reactions. In view of the combination of potent anti-histaminic and local anæsthetic activity of chlorpheniramine maleate and its isomers, and their possible use in topical application, it was considered important to determine whether these compounds produced skin sensitivity. Formulated preparations of the racemate and the two isomers were therefore examined for their possible irritant action upon shaved rabbit skin. Each preparation contained 2 per cent of anti-histamine and was applied twice daily for two weeks. There was no evidence of any degree of skin sensitization during this time with any of the preparations. After treatment had stopped, the rabbits were exposed to sunlight and daylight for a further two weeks; at the end of this time there was no evidence of any photosensitivity reaction in the treated areas of skin.

The experiments performed indicate that the pharmacological activities of both the (+) and the (−) isomers of chlorpheniramine maleate are qualitatively similar to those of the racemate. The (+) isomer is more active than the racemate as an anti-histaminic drug, but is less active as a local anæsthetic; the reverse is true with the (−) isomer. In view of this quantitative difference in activity, it is interesting to note that the acute intraperitoneal toxicities of the compounds in mice are similar. It is proposed to compare the possible anti-tussive action of each of these isomers with that of the racemate.

While this communication was being written, the results of some pharmacological investigations on the optical isomers of chlorpheniramine were reported by Roth and Govier[10], but no details of the resolution or physical constants of the isomers were given. Anti-histamine and central nervous system activity and toxicity were investigated; our results are in agreement with theirs with the exception of the anti-histaminic activity of the (−) isomer, which was reported to be only 0·01 of that of the racemate.

We thank the directors of Allen and Hanbury's, Ltd., for permission to publish this work, and Mrs. P. Hutchings, Mrs. G. Hayes, Miss R. Wilkins and Mr. R. Hornby for their technical assistance.

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MORPHOGENETIC RESPONSE OF *CITRUS* OVULES TO GROWTH ADJUVANTS IN CULTURE

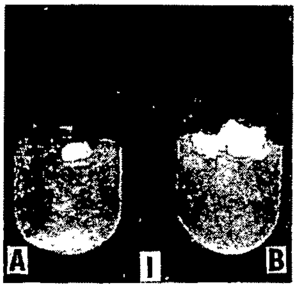
By N. S. RANGA SWAMY

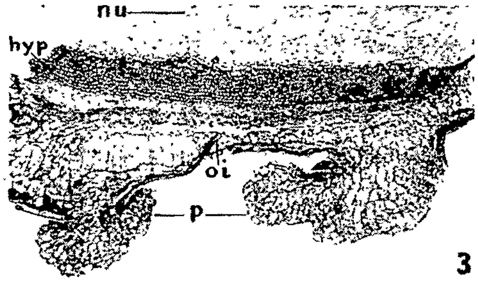
Department of Botany, University of Delhi

OUR understanding of the growth processes of ovules and their individual parts, namely, the integuments, nucellus, endosperm and embryo from inception to the adult stage, is incomplete. A study of the growth and differentiation of 'entire' ovules (pre- and post-pollination stages) using tissue-culture technique as a tool is of great use in unravelling the physiological and morphological changes that occur within them following pollination and fertilization. Apart from a few cursory reports, ovule culture is yet an unexplored field. White[1] and LaRue[2] secured a callus growth on the ovules of *Antirrhinum* sown in White's medium. The ovules of *Erythronium americanum* showed a four-fold increase in size and an irregular growth of their surface. With orchids, Withner[3] found ovule culture to be quite promising for shortening the period elapsing between pollination and maturation of the seed, and for hastening the production of seedlings. Recently, Nirmala Maheshwari[4] has reported that poppy ovules cultured at the 2-celled stage of the embryo on Nitsch's basic medium containing a mixture of vitamins, glycine, kinetin (0·4 p.p.m.) and indoleacetic acid (5 p.p.m.) grew to mature seeds capable of germination *in situ*.

From relevant literature, it would appear that no culture work has so far been done on ovules possessing adventive embryos. The present investigation was undertaken with the view of exploring the nature of response of ovules that are naturally polyembryonate to such growth supplements as coconut milk, tomato juice and malt extract.

Citrus microcarpa Bunge was chosen as the ovule source. The young fruits were surface-sterilized and the ovules dissected out. Ovules, in which nucellar embryos had been just initiated, were inoculated on White's medium which was used as control[5]. 3 and 5 per cent sucrose were also tried as carbon source and the growth adjuvants used were Seitz-filtered.





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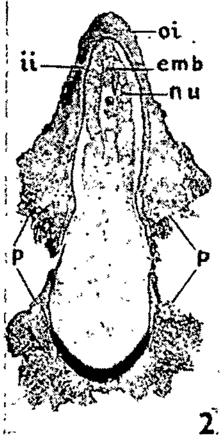

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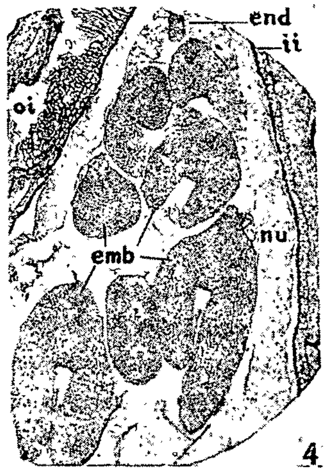

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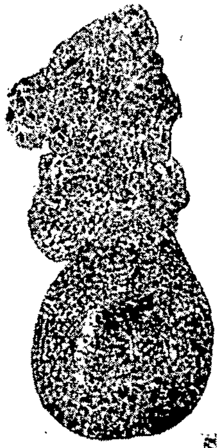

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Fig. 1. *A*, two-week-old culture of ovule on White's medium + coconut milk (40 per cent). Note the hypertrophy (× *c*. 0·3); *B*, same as *A*, on White's medium + malt extract (0·5 per cent) + sucrose (3 per cent). Observe the extensive growth of fragile tissue (× *c*. 0·3)

Fig. 2. L.S. ovule from Fig. 1*B* (× *c*. 5)

Fig. 3. L.S. chalazal portion of two-week-old ovule on White's medium + sucrose (5 per cent). Note the periderm formation (× *c*. 6)

Fig. 4. L.S. micropylar part of two-week-old ovule on White's medium + sucrose (5 per cent). Note the cellular endosperm along the periphery and embryos of different stages (× *c*. 4)

Fig. 5. L.S. embryo from two-week-old ovule on White's medium + tomato juice (20 per cent), showing proliferation from basal portion (× *c*. 30)

emb, embryo; *end*, endosperm; *hyp*, hypostase; *ii*, inner integument; *nu*, nucellus; *oi*, outer integument; *p*, periderm

In all the concentrations of sucrose, the ovules swelled and showed hypertrophy of the integument accompanied by surface undulations. Later, the integument ruptured at certain places, exposing masses of glistening white tissue. The proliferations were abundant over the entire surface of the ovule except the micropylar region. In this respect 5 per cent sucrose proved superior to other concentrations.

The control medium supplemented with coconut milk (40 per cent) gave a similar response, though it was less pronounced (Fig. 1*A*). With tomato juice (20 per cent) but without indoleacetic acid and vitamins, no appreciable change in hypertrophy was noticed when compared to the control. Proliferations were, however, extensive on White's medium + 0·5 per cent malt extract (Figs. 1*B*, 2). The entire surface of the ovule showed intumescences which were of a more or less friable nature. Subcultures of such detached tissue masses did not prove successful.

Microtome sections of treated ovules revealed the following features.

The outer integument was potentially proliferative. Although no mitoses were observed, the arrangement and differentiation of the cells in a regular fashion indicated that the new tissue arose by cell divisions rather than by mere cell enlargement. The intumescent tissue originated mainly from the cambium-like cells of the sub-epidermal layers of the integument. The tissue showed 2–3 layers of tangentially elongated cells containing dense cytoplasm and a prominent nucleus. Outside these were cells which had a more vacuolate cytoplasm and degenerating nucleus; and the outermost 2–3 layers of cells were suberized. The whole structure simulated a periderm tissue (Fig. 3). In some cases isolated tracheidal cells were also found in the proliferated tissue. The inner integument did not show any response to the various treatments.

No appreciable growth of embryos was noticed in ovules cultured on White's medium containing 2 or 3 per cent sucrose. But in those on 5 per cent sucrose, the proembryos enlarged in size by cell divisions and differentiation occurred in 2 weeks (Fig. 4). However, a considerable variation in their development was met with and different stages could be seen in the same ovule. On White's medium plus tomato juice a similar response was obtained. Some embryos showed proliferations from the basal region (Fig. 5). No differentiation of embryos could be achieved either on coconut milk or malt extract.

The endosperm tissue was generally inhibited and was attenuated during development, but in ovules grown on White's medium containing varying concentrations of sucrose its growth was normal, and 2–3 layers of endosperm could be observed bordering the embryo sac. The nucellar tissue was unaffected by growth modifiers except that the cells were much elongated along the axis of the ovule.

Briefly, then, the ovules of *Citrus microcarpa* cultured on different media became hypertrophied and irregular in outline, especially so on malt extract, perhaps due to osmotic gradients in the medium. A periderm-like tissue was formed from the outer integument in almost all the treatments. It is interesting to note that proembryos when excised and cultured on White's medium showed no growth[5], whereas in cultures of whole ovules the growth and differentiation of the embryos proceeded normally. The artificial induction of budding of proembryos obtained by exogenous application of growth factors, such as tomato juice, is significant as a source of securing identical progeny.

I am grateful to Prof. P. Maheshwari and Dr. S. Narayanaswami for guidance, encouragement and helpful suggestions. Thanks are due to the Council of Scientific and Industrial Research, New Delhi, for financing a scheme of research on *in vitro* culture of plant organs under which this work was carried out.

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Origin of the Lunar Craters and Maria

I am prompted to tender a few pertinent comments on the recent communication by Prof. Zdenĕk Kopal[1].

The physiographical similarity between many of the lunar craters and those produced by man-made explosions has been pointed out by Baldwin[2], and, if one dare assume that at least some of the lunar craters were produced by impacting objects, one can make use of this similarity and the present state of knowledge on the strong shock hydrodynamics of explosive cratering in estimating the relative energies involved and—with a slightly greater uncertainty—the masses which produced them. My own analysis, which I hope to publish shortly, leads me to believe that Baldwin's energy figures should be revised sharply upwards, that is, that the kinetic energy of an impacting mass would have to be of the order of 10^{28} ergs to produce a crater twenty miles in diameter, and one expects the diameter to vary as the cube-root of the impacting energy. While the energy partition in a venting underground explosion depends critically on the depth of penetration, present experience indicates that as much as one-half the incident energy may be absorbed in ground shock for deeply penetrating explosions. Most of this energy is absorbed in irreversible heating of the rock in a very short distance, and when the shock pressures have degraded to the order of the elastic strength of rocks (about 1 kilobar), the energy available for propagation as seismic waves is not likely to be more than 1 per cent of the incident energy.

Thus we are back again to a figure like 10^{26} ergs of seismic energy emanating from an impact capable of producing a crater 20 miles in diameter. I believe also that it is not unfair to seismologists to state that there is a disagreement of at least three orders of magnitude in the total seismic energy from the largest terrestrial earthquakes, with 10^{25} ergs as the lowest estimate. Thus it is not unreasonable to presume that the formation of a crater as large as Alphonsus would be accompanied by a moonquake of comparable intensity to the largest earthquakes, and the presence of craters twice as large as Alphonsus implies an increase of one order of magnitude in the seismic energy. In contradistinction to earthquakes, the seismic energy from an explosion is preferentially concentrated in the P-phase, with very little going into S-phase (Rayleigh waves), and the region undergoing substantial Earth motion is confined to within one or two crater radii. It appears extremely doubtful that even the largest craters, if attributable to impact, would exhibit widespread damage visible from the Earth.

With regard to conditions at the anti-focus, even if one disregards the difference in arrival times (of Rayleigh waves exclusively) due to anisotropy and non-sphericity of the lunar globe, and admits an energy concentration an order of magnitude below that at the source, there is little reason to expect any pronounced physical disturbance at the assumed caustic. The early processes in the production of seismic energy at the source are irreversible; certainly no crater would be formed. A more likely situation would be the local enhancement of ground motion, but probably never exceeding the elastic limit of the rock.

Prof. Kopal postulates that an impacting cometary mass possessing 10^{31} ergs of kinetic energy could produce 10^{20} gm. of molten lava. The results of the 'Ranier' underground atomic test in Nevada[3] indicate that less than 0·1 per cent of the total mass of material within the fracture zone was fused, and that cooling of the entire volume to temperatures like 100° C. took place in less than 1 hr. Although the equivalent of one-half the thermal energy of the bomb was required to fuse this mass of material, resolidification (if it was ever melted at all) occurred almost immediately, and the fused material was brecciated and intermingled with other debris when the cavity collapsed. In the case of a surface, or near surface, explosion, one would expect that the fused material would be thrown out of the crater along with the other debris, and not collected as a molten pool in the bottom of the crater. The distribution of fused material around the Canyon Diablo crater already supports this hypothesis.

William G. van Dorn

University of California,
Scripps Institution of Oceanography,
La Jolla,
California. Jan. 29.

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[2] Baldwin, R. B., "The Face of the Moon" (Chicago Univ. Press, 1949).

[3] Preliminary Report of Operation Plumbob, University of California Radiation Laboratory, Report 5124).

If Dr. van Dorn is right in concluding that the energies of meteor impacts necessary to produce lunar craters of given size are actually about 100 times larger than those postulated by Baldwin, the seismic arguments put forward in my letter of January 17 would be correspondingly strengthened; for the available estimates of the largest energies of terrestrial earthquakes range between 10^{23} and 10^{27} ergs, with 10^{25} ergs as a fair average (Gutenberg, 1958).

The fact that seismic energies of terrestrial surface explosions are spent preferentially in the P-waves is of no direct lunar relevance; for, first, the epicentres of lunar meteor explosions should be at least a few thousand yards deep (that is, far from pure surface phenomena in the terrestrial sense); and, secondly, the much lower gravity would allow S-waves on the Moon to attain greater amplitudes than on the Earth. Moreover, the real point of my communication was to direct attention, not to the damage caused by seismic waves in the immediate neighbourhood of an impact, but rather to the cumulative effects which hundreds of thousands of such occurrences would be bound to entail, and which have not been paid any attention in all previous work.

The focusing (however imperfect) of lunar S-waves in the anti-focal region should produce increased fragmentation and destruction, rather than any new crater. Whether or not the elastic limit of rock could be attained remains wholly conjectural.

Lunar comet impacts and terrestrial nuclear explosions differ by so many orders of magnitude in mass, energy, as well as temperature (quite apart from different gravity and absence of atmosphere around the Moon) that scarcely any valid conclusions can be drawn from their comparison. On the other hand, to postulate the occurrence of hundreds of thousands of major meteor impacts on the Moon without simultaneous consideration of the collisions with comets would be so grossly at variance with the present frequencies of both types of bodies as to make little or no astronomical sense. As the meteor impacts on the Earth or the Moon must be accepted as facts, and their effects traced, the same must be true of the comets ; and if lunar maria are not the results of such encounters, what else have comets done to the Moon?

ZDENĚK KOPAL

Department of Astronomy,
The University,
Manchester.

Low-Energy Corpuscular Radiation at High Latitudes

IN high latitudes, at altitudes of order 100 km., a flux of electrons (50–90 keV.) dependent on latitude has been detected[1]. Protons of energy up to at least 90 keV. appear in auroræ[2]. I propose an explanation of this observed high-latitude corpuscular radiation on the basis of an acceleration mechanism discussed by Bohm and Gross[3].

This mechanism involves travelling (electron) electrostatic waves satisfying the dispersion relation :

$$V^2 = \frac{w^2}{K^2} = \frac{4\pi n e^2}{mK^2} + \frac{3kT}{m}$$

where V = phase velocity of the wave ; w = angular frequency of the wave ; K = wave number of the wave ; n = electron density ; e,m = charge, mass of electron ; k = Boltzmann's constant ; and T = temperature of region. Charged particles can be trapped[4] between the potential crests of such a wave and carried with velocity V, which increases as the wave is propagated into regions of increasing electron density.

Bohm and Gross[4] showed that electrostatic waves are infinitely damped as their wave-number approaches the lower limit $2\pi(kT/\pi^2 ne^2)^{1/2}$. Hence, their band of allowable frequencies is given by :

$$\frac{4\pi n e^2}{m} \leqslant w^2 \leqslant \frac{4\pi n e^2}{m}\left(1 + \frac{3\pi}{4}\right)$$

From this it is seen that the maximum possible penetration of an electrostatic wave generated in a region of electron density n is to one of electron density $\left(1 + \frac{3\pi}{4}\right) n$.

I suggest that electrostatic waves are generated in the exosphere by solar corpuscular streams. The waves are propagated along the geomagnetic field lines, trapping charged particles and accelerating them down to levels where the electron density has increased by at most a factor $\left(1 + \frac{3\pi}{4}\right)$. At these levels the energy of the waves will have been fully converted to kinetic energy of particles moving down along the geomagnetic field lines.

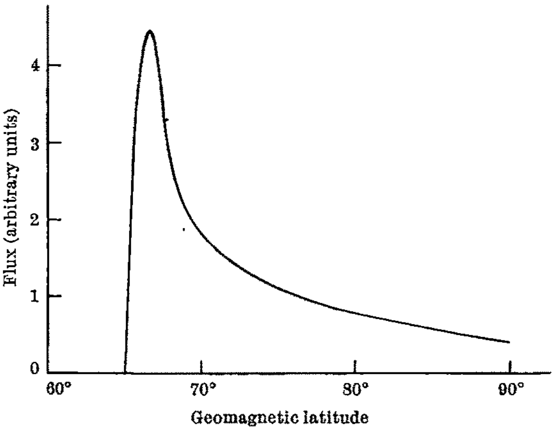

Fig. 1. Calculated variation with geomagnetic latitude of the flux of low-energy corpuscular radiation at the Earth

For purposes of calculation it is assumed that the electrostatic waves are generated at a spherical surface of radius 6·5 Earth radii and the trapping and accelerating region to be a spherical shell one Earth radius thick. Further, the flux of accelerated particles is assumed to be proportional to the volume of their trapping and accelerating region.

The calculated variation of accelerated particle flux with geomagnetic latitude is then of the form illustrated in Fig. 1. This closely fits the observations of Van Allen[1] for electron flux and resembles the latitude distribution of auroræ[5].

An estimate follows of an upper limit of the mean absolute flux, F, of accelerated protons (or electrons) at the Earth's surface. It is assumed that the energy of solar particles captured by the exosphere is fully converted to energy of electrostatic waves and then to energy of trapped particles. Hence, ignoring the kinetic energy carried by electrons :

$$sV_0\pi\alpha^2 \times \tfrac{1}{2}mV_0{}^2 = F \times f \times 4\pi a^2 \times \tfrac{1}{2}mV_1{}^2$$

where s = number density of protons (or electrons) in the solar particle stream, V_0 = velocity of solar particles, α = radius of spherical surface at which electrostatic waves are generated, m = proton mass, f = fraction of Earth's surface on which accelerated particles are precipitated, a = radius of Earth, V_1 = velocity of accelerated particles.

Taking s = 10 cm.$^{-3}$, $V_0 = 10^8$ cm. sec.$^{-1}$, $V_1 = 10^9$ cm. sec.$^{-1}$, $\alpha = 6\cdot5\, a$, $f = 0\cdot1$ (polar regions) leads to $F \approx 10^9$ cm.$^{-2}$ sec.$^{-1}$. This might be compared with the value 6×10^7 cm.$^{-2}$ sec.$^{-1}$ inferred by Chamberlain[6] for the flux of protons in auroræ and the value $10^6 - 10^8$ cm.$^{-2}$ sec.$^{-1}$ from Van Allen[1] for the flux of electrons.

From the above dispersion equation it is seen that this discussion is untenable unless $T \leqslant \frac{mV_0{}^2}{3k}$ in the particle-trapping region. For $V_0 = 10^8$ cm. sec.$^{-1}$ then we must have $T < 20{,}000°$ K.

K. D. COLE

Antarctic Division,
Department of External Affairs,
Melbourne, C.1.

Feb. 2.

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Gravity Survey on the Kuttyaro Caldera by means of a Worden Gravimeter

LAKE KUTTYARO, in the eastern part of Hokkaido, Japan, is the western half of a circular caldera, which is one of the largest in the world, being about 20 km. in diameter. A small island at the centre of the lake and parasitic volcanoes in the other half of the caldera are supposed to have erupted after its formation.

At present, gravity measurement on the water is very difficult. Fortunately, we were able to use a Worden gravimeter on the surface of Lake Kuttyaro because it freezes hard in winter. It is noteworthy that the free air reduction and the Bouguer correction are uniform over the lake, and the topographical correction is very small in this region. A survey on the ice was carried out in March 1958. The Bouguer anomalies obtained on and near the lake (Fig. 1) display a relatively low anomaly of about 46 milligals, concentrated at the centre of the caldera. Comparing the distribution of the Bouguer anomalies with that of the depth of the lake (Fig. 2), it is clear that the Bouguer anomalies are almost independent of the minor structures of the surface of the ground and the depth of the lake, and must be related to the subterranean structure on a larger scale. Analysis of the distribution of the Bouguer anomalies shows that coarse material with a density about 0·3–0·5 gm./cm.^{3} smaller than that of its surroundings has accumulated at a depth of 3–4 km. beneath the lake. This coarse material is supposed to be pumice ejected during the formation of the caldera, such as is actually found widely spread over the surface of the ground in the neighbourhood. The distribution of the Bouguer anomalies gives the total mass-defect which is responsible for the low anomaly as 10^{11} tons. This value coincides with an estimate by Y. Katsui (Geological Institute, Hokkaido University), who has studied the distribution of the ejected pumice. The mechanisms by which enormous amounts of pumice were ejected and the caldera was formed cannot be elucidated by gravity survey alone, but the eruption, accompanied by the accumulation of pumice, must clearly have been so violent that the region from the surface to a depth of 3–4 km. was completely devastated.

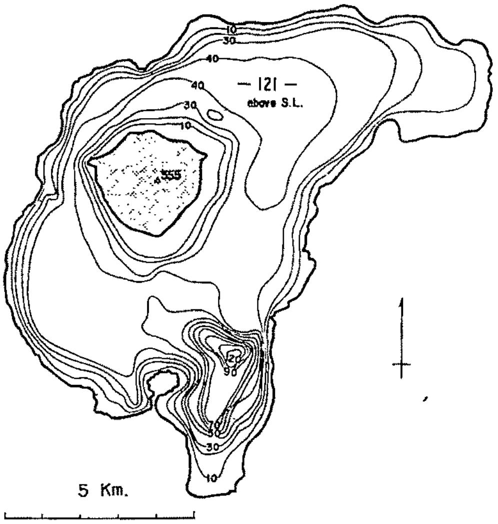
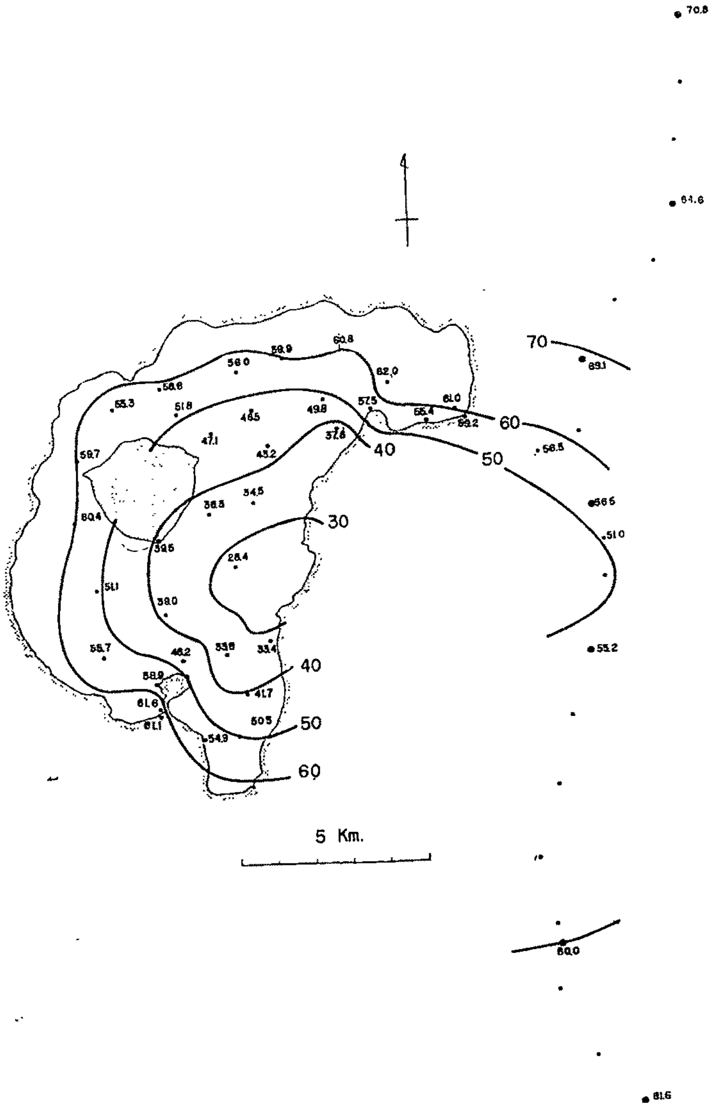


Fig. 2. Depth contours in Lake Kuttyaro (in metres)



ig. 1. Distribution of the Bouguer anomaly (in milligals)

From a petrological discussion of the pre- and post-caldera lavas, H. Kuno[1] classifies the Japanese calderas as belonging to the Krakatoa or the Glencoe types of H. Williams[2], according to the cause of their formation. An example of the former type is the Kuttyaro caldera, which collapsed into the magma reservoir accompanying the eruption of a tremendous amount of pumice; and one of the latter type is the Mihara caldera, Oosima Volcano, which was formed by the subsidence of a great mass of rocks into the magma reservoir, without the eruption of pumice. We fear that the term 'magma reservoir' in this account lacks confirmation. From this geological point of view we should expect to observe low Bouguer anomalies on calderas of the Krakatoa type and high Bouguer anomalies on calderas of the Glencoe type. Actually, the result of a gravity survey carried out on the Volcano Mihara[3] shows a high anomaly, amounting to about 15 milligals. This fact, and the low Bouguer anomaly observed on the Kuttyaro caldera, seem to justify the proposed geological classification based on the formation of the calderas, but the mechanism of subsidence or collapse is another problem which we regard as unsolved.

A full account of gravity surveys on several volcanoes in Japan will be published elsewhere.

This work is being continued while one of us (I. Y.) is studying at the Istituto di Fisica Terrestre, Università di Napoli.

We wish to thank Prof. C. Tsuboi, who encouraged us throughout the course of this work.

IZUMI YOKOYAMA
Geophysical Institute,
Hokkaido University,
Sapporo.

HIROKAZU TAJIMA
Earthquake Research Institute,
Tokyo University.

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Measurement of the Flocculation of Suspensions

I HAVE read with interest the communication by R. L. Whitmore in *Nature* of January 31, p. 313, on the devolopment of a test which was introduced by Prof. Fahraeus in 1958.

We have been using this method for testing 'Oildag' (colloidal graphite in oil, Acheson Industries (Europe), Ltd.) dispersions since 1939, and have, in fact, developed a special apparatus which allows a roll of Whatman No. 4 filter paper to be folded into a pack of 25 or more papers. The 'Oildag' concentrate is diluted with *SBP*.3 fluid, poured into the reservoir and allowed to flow through under gravity. A typical 'chromatogram' obtained by this method is shown in Fig. 1.

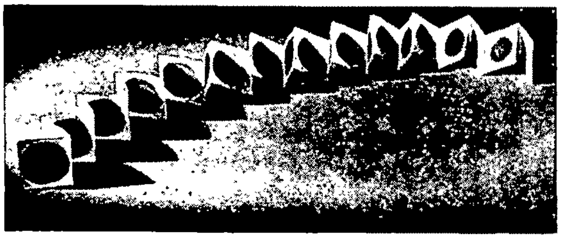

Fig. 1

I might add that we have supplied this test rig to people in many countries, as we found it a very easy method of distinguishing quickly between 'Oildag' and less stable dispersions of graphite in oil.

E. R. BRAITHWAITE
Research and Development Department,
Acheson Colloids, Ltd.,
P.O. Box 12,
Plymouth. Feb. 9.

β-Type Interlamellar Sorption Complexes

IN what we have called[1] the 'β-type' interlamellar sorption complexes of graphitic acid, the sorbed molecules are probably standing normally to the layers of the sorbate. The β-complexes with normal straight-chain amines, which we have been investigating, are particularly interesting, since they are formed over a complete range of chain-lengths.

Our new results are plotted in Fig. 1. Between 4 and 16 carbon atoms, the spacing rises linearly with the chain-length, and the slope of the line is 2·6 A. per carbon atom. This corresponds almost exactly to the projected length of two C—C single bonds, and indicates that there are two layers of sorbed molecules oriented normally to the sorbate layers. Fig. 1 shows a slight shift at 10 carbon atoms. We will not enlarge here on possible reasons for this.

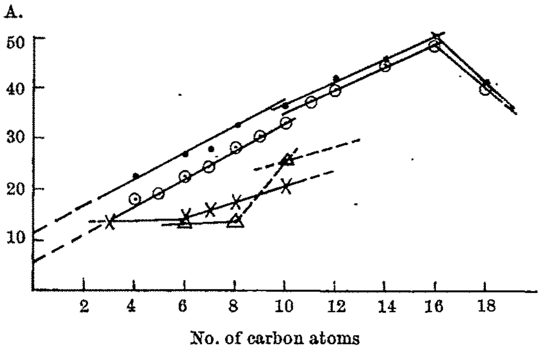

Fig. 1. Basal spacings plotted against chain-length of sorbed compound. ●, *n*-Amines with montmorillonite; ⊙, the same with graphitic acid; △, diamines with montmorillonite; ×, diamines with graphitic acid. Note that the diamines give half the slope of the *n*-amines, corresponding to only one layer of molecules

The actual value of the layer separation is, however, too low to accommodate two fully extended molecules. It seems necessary to assume, therefore, either that the free ends of the molecules overlap (to the same extent in each complex) or that the first two or three terminal carbon atoms, next to the amine group, are in contact with the sorbate layer, the rest of the molecule being turned around at right-angles. The last-mentioned supposition seems to us the more probable.

Beyond 16 carbon atoms, the spacing drops again, and this must apparently correspond to a tilting of the molecules. Unfortunately, only one amine in this range (octadecane-1-amine) was available to us.

We were rather surprised to find that completely analogous results are given by montmorillonite (upper graph of Fig. 1). These results are, however, not really in contradiction with those of Jordan[2], who found a flat orientation of long-chain amines, since in his case the amines were in ionic form, and in

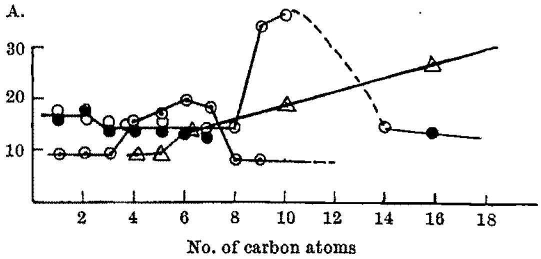

Fig. 2. As Fig. 1. ○, *n*-Alcohols with montmorillonite (Barshad); ●, same (MacEwan); ⊙, same with graphitic acid; △, glycols with graphitic acid

amounts roughly equivalent to the cation exchange capacity of the clay. In our experiments the amine was always in the form of the pure liquid. Recent work of Hofmann and collaborators[3], however, shows that even with ionic amines, β-type complexes can be formed.

Straight-chain alcohols also give β-complexes with graphitic acid, but over a much narrower range of chain-lengths (Fig. 2). These have been previously described[1], but in the light of our new results their nature becomes clearer. Barshad[4] has described what now seem to be β-type complexes formed by nonanol-1 and decanol-1 with montmorillonite. They are quite analogous to the graphitic acid complexes. Barshad's results are plotted in Fig. 2, together with ours.

F. Aragón
J. Cano Ruiz
D. M. C. MacEwan

Carnegie Laboratory of Physics,
Queen's College,
Dundee. Jan. 29.

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Size Distribution of Tobacco Smoke Particles

Tobacco smoke from ordinary untipped proprietary branded cigarettes was collected directly on to various support films used in electron microscopy. 'Formvar' films were found to be most satisfactory in terms of particle resolution and film strength; with carbon, for example, the particles appeared to flow into one another more readily.

Smoke was allowed to impinge directly for about 5 sec. on to a 'Formvar'-covered electron microscope grid held within 1 cm. of the glowing end of a free-burning cigarette. Electron micrographs were taken at an instrumental magnification of 2,000 and the images of the smoke particles measured by an optical microscope (× 70) with a calibrated eyepiece graticule representing a spacing of 0·14μ on the original specimens.

Fig. 1*a* shows the resulting histogram of 1,200 particles obtained from three different electron microscope fields of view (such as Fig. 2*a*). The shaded area of each column represents the standard deviation obtained by using the results sequentially as 12 random samples of 100 observations each.

The histogram of Fig. 1*b* was obtained in a similar way for smoke collected 1 cm. from the mouth end of a cigarette (Fig. 2*b*). This was effected by puffing air from a small hand bellows through the cigarette from the burning to the mouth end, which simulates to some extent the conditions during the act of smoking. The extra dust particles observed in this case are recognizable by their shape and were ignored in the size analysis.

In order to test the filtering action, if any, of the lungs, the histograms of Figs. 1*c* and 1*d* were plotted, each of 800 particles. The former resulted from a brief inhalation, at the normal breathing-rate, while the latter resulted from a deep inhalation involving holding the breath for about 2 sec.

Although it may be tempting to draw immediate conclusions from histograms 1*a* to 1*d*, it became apparent during this work that the distribution of particle-size depended on the average age of the particles. As the age of the smoke increased, the particles tend to coalesce giving a greater proportion of larger particles at the expense of smaller particles, a fact easily demonstrated by collecting the smoke at different distances from the burning end of the cigarette.

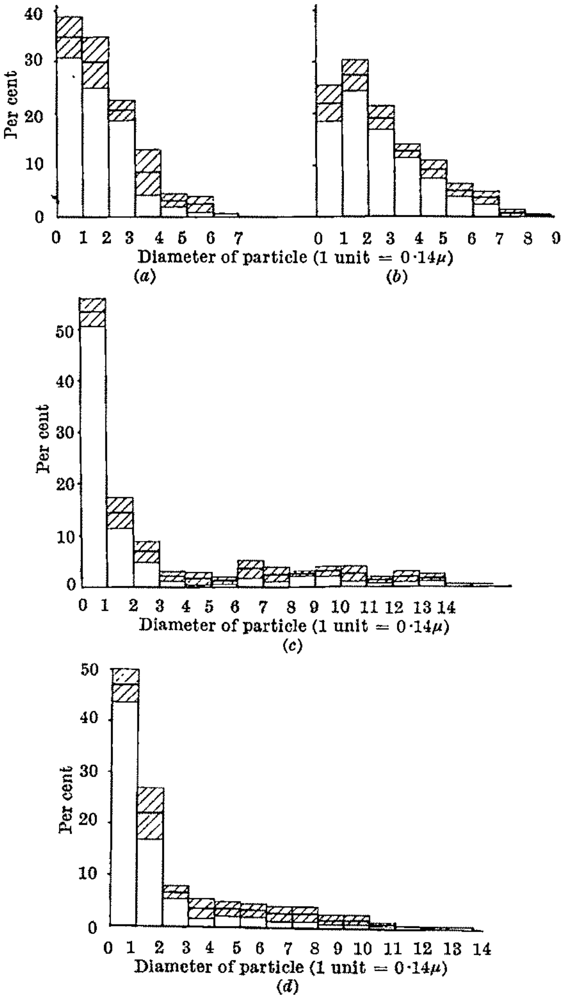

Fig. 1. Histograms showing particle-size distribution of tobacco smoke: (*a*) smoke taken directly from glowing end; (*b*) filtered through cigarette; (*c*) held briefly in lungs; (*d*) inhaled deeply

In order to obtain measurements of the aging of smoke, a glass tube, 10 ft. long and 2 in. in diameter, containing small ports at 1-ft. intervals along its length, was arranged horizontally and smoke from the glowing end of a cigarette was drawn at a speed of 1 ft./sec. along the tube by a pump at the other end.

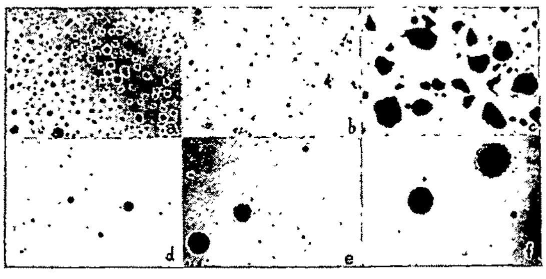

Fig. 2. Electron micrographs of tobacco smoke (× 700): (*a*) smoke taken directly from glowing end; (*b*) filtered through cigarette; (*c*) sedimented for several hours; (*d*), (*e*), (*f*) effect of aging for 1, 5, and 9 sec., respectively

The flow was laminar so that little exchange with the walls occurred. Microscope grids were placed in different ports to collect the smoke at different ages.

Two effects of age were apparent : first, the obvious increase in particle-size (Figs. 2*d*, *e* and *f*) and, secondly, a departure from regular circular cross-section and a greater boundary diffuseness, particularly for the smaller particles. This latter effect, together possibly with other effects as yet not elucidated, made it impossible to obtain histograms of acceptable consistency from field to field. Experiment showed that this was not due to evaporation of volatile components in the electron beam, as has been observed by Trillat and Cuzin[1]. Very long-period sedimentation under static air conditions produced quite different particle shapes, as shown in Fig. 2*c*.

It is clear that the 'age' of the smoke is of great importance, and its effects must be clearly understood before interpretation of distribution curves may be attempted, a situation which is not yet attained. Even so, 1,000 observations are too few for reliable conclusions to be drawn from them. Nevertheless, it appears that some filtering of the smaller particles, together with increase of size due to aging, is indicated by the greater number of larger particles observed after the smoke has passed through the cigarette ; also subsequent inhaling of smoke into the lungs causes the particle sizes to be redistributed in a different way, possibly by removal of the particles of size $\sim 0{\cdot}3\mu$.

It is noteworthy that only very rarely are droplets observed surrounded by a cloud of small satellites as occurs in many of the beautiful photographs presented by Kahler and Lloyd[2]. Such satellites, we believe, are essentially a product of the electrostatic precipitation technique employed, which is therefore unsuitable for determination of particle-size.

Helpful discussions with Mr. A. Horseman of the Imperial Tobacco Co. (of Gt. Britain and Ireland), Ltd., are gratefully acknowledged.

ELAINE HARRIS
H. F. KAY

H. H. Wills Physics Laboratory,
University of Bristol.

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Detecting Volatile Airborne Droplets

Liddell and Wootten[1] have described a method for sampling fog droplets in a suitable form for measurement under the microscope. In this, microscope slides were coated with a gelatin film which incorporated a purified dye. When water droplets impinged on this film a characteristic dark crater-like ring remained after evaporation of the droplet. The film gave a permanent sample and when ideally prepared detected fog droplets down to 1μ. The ratio of the diameter of the ring to the original droplet was constant.

I have recently found that by eliminating the rather troublesome dye and viewing the pure gelatin film with positive phase-contrast the method becomes one of extreme reliability, simplicity and sensitivity. (Fig. 1*a*. These droplet traces are virtually invisible with ordinary illumination.) To support the film, microscope slides are used which have been cleaned in a hot acid cleaning mixture (for example, chromic–sulphuric) and stored in 'Tergitol' solution. A slide is wiped dry with a clean cloth and a thin film of a warmed gelatin solution of about 5 per cent concentration is spread evenly with a glass rod. The slide is gently heated until the film is quite dry, when it is ready for use.

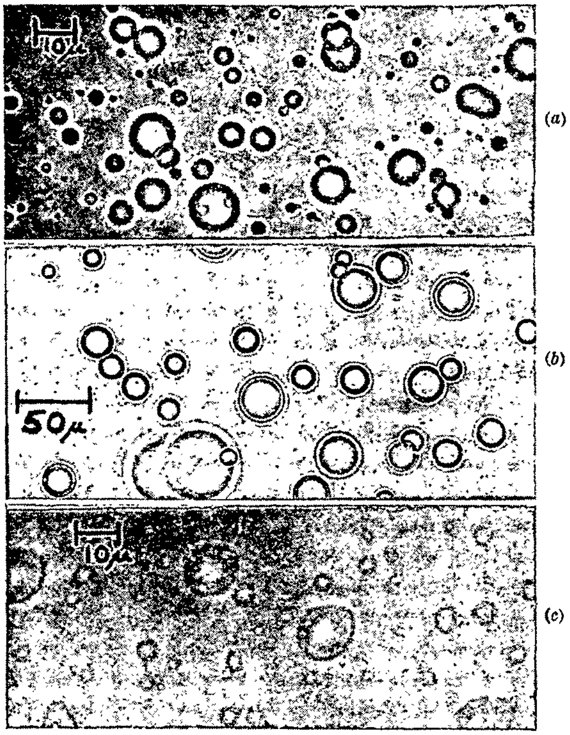

Fig. 1. Photomicrographs of traces left by volatile droplets. Scales refer to the original droplet diameters, not to the trace diameters. The samples were taken in a special form of two-stage reciprocating-slide impactor. (*a*) Fog droplets from second stage of impactor ; impacting jet velocity, 60 m.p.h. ; objective, 4-mm. phase-contrast. (*b*) Fog droplets from first stage of impactor ; jet velocity, 5 m.p.h. ; objective, 8-mm. phase-contrast. (*c*) Kerosene droplets on *R*230 silicone resin ; second stage of impactor, 60 m.p.h. ; objective, 8-mm. phase-contrast

For the smallest droplets, say $< 10\mu$, the thickness of the dry film does not seem to be critical, but for larger droplets the thickness is optimal at about 1μ (which can be judged by the interference fringes) as thinner films give very faint rings and thicker ones may give rather confusing halo effects as in Fig. 1*b*.

As an alternative to glass, films of clear gelatin on a clear flexible base may be obtained from photographic film manufacturers and are useful when curved impingement surfaces are required. Gelatin films may be used repeatedly or rejuvenated after long storage by rinsing quickly with distilled water and re-drying.

The method is of greatest value for droplets $< 10\mu$ where other methods such as the widely used magnesium oxide method[2] or impingement into oil or grease become unreliable. Sharp images of the traces of droplets well below 1μ in diameter are seen in Fig. 1*a*. It will be noted that in counting and sizing work, overlapping traces give no trouble except when a large drop completely overlaps and obliterates a small trace. For droplets $> 10\mu$ phase-contrast illumination is not essential, but the gelatin film method is not necessarily superior to the magnesium oxide method in this range.

In work in actual fogs using a special form of droplet impactor, as will be reported elsewhere, a factor was found for drop diam./ring diam. of 0·59, in agreement with laboratory calibration. In local fogs the method has revealed large numbers of droplets in the 1μ region as in Fig. 1*a*. A valuable feature is that the perfect optical quality of the gelatin film enables the insoluble content of the droplets, such as their condensation nuclei, to be seen and counted. The plurality of such particles in most droplets more than a few microns in diameter suggests that collision and coalescence of fog droplets is very common. A 50μ droplet may contain 50 or 100 discrete insoluble particles of 1μ or less.

Obviously, the principle of the water-sensitive gelatin film should be applicable to the detection of volatile droplets of other liquids, provided that a clear film, soluble in that liquid, can be prepared. A requirement known to me was the detection of kerosene droplets in combustion chambers. Screening tests of many kerosene-soluble substances were carried out and a satisfactory film was found in silicone resin *R*230 (I.C.I., Ltd.). This is spread on a slide and heated off in exactly the same way as for gelatin film. Contrast of the kerosene droplet traces after evaporation is not quite so good as for water on gelatin, but the phase-contrast microscope enables the traces to be seen clearly down to 2μ diam., representing droplets of 0·8μ, as the droplet/ring factor in this case is 0·4 (Fig. 1*c*).

There is no reason to doubt that suitable clear, soluble films could be found for the detection of a wide range of volatile liquids in the manner described.

K. R. May

Microbiological Research Establishment,
Ministry of Supply,
Porton, Wiltshire.

Feb. 11.

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Light Emission from Insulating Liquids due to Excitation by d.c. Fields near Breakdown

In scintillation counter applications[1,2], it is well known that dilute solutions of fluorescent organic materials, such as anthracene, in suitable organic solvents will absorb radiation and re-emit at a wave-length characteristic of the solute, when the liquid is excited by ultra-violet or high-energy particles.

While investigating pre-breakdown pulse activity and conduction currents in highly degassed and dehydrated transformer oil of Peruvian origin, it was found that visible light was emitted from the high-stress region at d.c. fields in excess of 600 kV./cm. So far as I am aware, this has not been observed previously in organic liquids. Tests were carried out in uniform fields between 1-cm. diameter nickel and stainless-steel electrodes, with a gap spacing of 89μ. The colour and frequency of the emitted light were similar to the blue fluorescence observed when the oil was excited with an ultra-violet source.

No detailed chemical results are available on the composition of the oil; but it is known that traces of unsaturated polycyclic aromatic compounds are present, and that these give rise to the fluorescence of the oil. In order to test the suggestion that light emission was due to excitation of molecules of this type, observations were made using spectroscopic grade hexane, and hexane samples doped with scintillation grade anthracene and *p*-terphenyl, dissolved at a concentration of 1 gm./l. No visible light was observed with pure hexane up to fields of 1·1 mV./cm., but light emission, characteristic of the dissolved impurity, was observed in the doped hexane samples.

Microscopic observations of this emission showed, for stresses from 600 to 950 kV./cm., filamentary luminous streamers which completely bridged the oil gap from cathode to anode, with no apparent change in intensity along its length. At higher stresses, the glow appeared to become diffuse over the high-field region.

The light intensity was found to increase in an exponential manner with increasing field, but no noticeable change occurred in the spectrum of the emitted light. Removal of the impurities was found to increase the breakdown strength. For example, fractional distillation of the oil, thus removing most of the fluorescent impurities, raised the breakdown strength of the degassed oil from 1,100 to 1,300 kV./cm. Similarly, the breakdown strength of the doped hexane was raised from 700 to 1,050 kV./cm. by removal of the added impurity.

It is possible that the light emission was due to micro-discharges in the oil rather than excitation of the fluorescent impurities in the liquid phase. By means of a metal bellows, pressure and tension was applied to the liquid in the test cell. No variation in the light intensity was observed, and fracture of the liquid did not occur when the liquid was subjected to tension at pre-breakdown fields in excess of 1,000 kV./cm.

These experiments indicate that fluorescent impurities, such as anthracene, which absorb energy by resonance of electron orbitals into higher states, may be excited by high d.c. fields in the liquid phase, and that the processes involved play some part in the processes which lead to electrical breakdown.

Acknowledgments are made to Prof. Humphrey Davies for the provision of facilities, to Dr. H. Tropper and colleagues of the Dielectrics Team for encouragement and discussion, and to the University of Queensland for the award of a Travelling Research Fellowship.

M. Darveniza

Electrical Engineering Department,
Queen Mary College
(University of London),
Mile End Road,
London, E.1.

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CHEMISTRY

Analysis of Hydrocarbons

The difficulty of separating a mixture of ethane, ethylene, propane and propylene on a single column in gas-phase chromatography has been commented on recently[1]. Drs. Barnard and Hughes also mention the difficulty of using some two-stage columns. This mixture can in fact be readily separated on a single column. If it is required to analyse only small samples, a column packed with alumina may be used, either thermostatted at one temperature[2] or by 'temperature-programming' the column[3]. When both

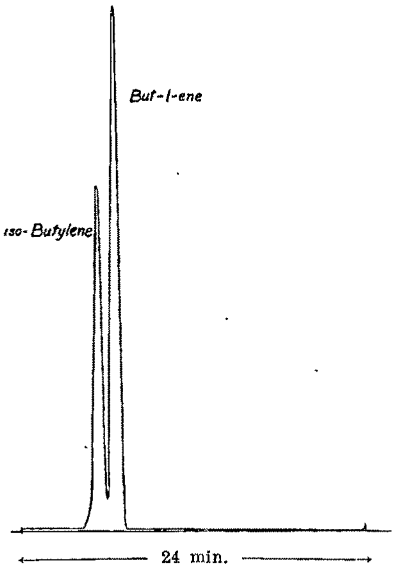

Fig. 1. 25-ft. acetonylacetone column ; 0° C. ; flow gas, hydrogen, 30 ml./min.

small and large samples have to be analysed, it is an advantage to use gas – liquid chromatography, and a single column of dimethylsulpholane on firebrick may be used[4]. Two-stage columns have also been used successfully to carry out this separation[4]; further, a commercial column is manufactured with which this analysis can be carried out[5].

In this laboratory this mixture has been analysed repeatedly on a single column, packed with acetonylacetone on firebrick (a copper coil, 25 ft. × ¼ in.) operated at 0° C. This column not only resolves the hydrocarbons mentioned, but also resolves nearly all the possible isomers of the C_2 to C_5 hydrocarbons, including many cyclic isomers, in a total running time of 1 hr. The column may be used to carry out the difficult analysis of *iso*butylene and but-1-ene in the presence of the other hydrocarbons. Fig. 1 shows the resolution obtained with this column and a mixture of *iso*butene and but-1-ene.

This column does not resolve 1,1-dimethyl*cyclo*propane and 3-methyl but-1-ene, two compounds which have closely similar boiling points. However, these compounds are easily separated using a solution of silver nitrate in ethylene glycol on fireclay. No difficulty has been experienced in using a short glass column (3 ft. × ¼ in.) packed with this material and attached to the end of the acetonylacetone-packed column. Such a double column allows this difficult separation to be carried out and still allows the other C_2 to C_5 hydrocarbons to be separated (see Fig. 2). A mixed column of these two packings has been used successfully, but was found to have a relatively short 'life' when compared with the double column.

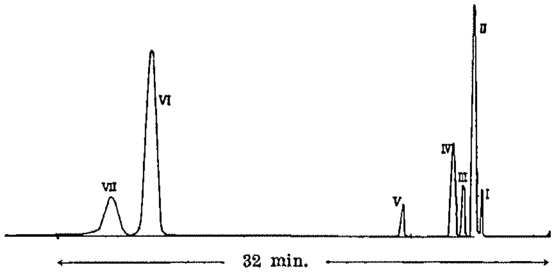

Fig. 2. Double column ; 0° C. ; flow gas, hydrogen, 30 ml. per min. I, Ethane ; II, ethylene ; III, propane ; IV, propylene ; V, *n*-butane ; VI, 1,1-dimethyl*cyclo*propane ; VII, 3-methylbut-1-ene. Ethylene peak has been attenuated by a factor of 10

H. M. FREY

Department of Chemistry,
University,
Southampton.
Jan. 28.

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DR. FREY'S letter is of considerable interest. We were, of course, aware of several methods reported in the literature for the separation of the C_2 and C_3 hydrocarbons. However, the purpose of our original communication was to direct attention to a *simple* method of separating the lower hydrocarbons, not involving any of the complexities of very long coiled columns, temperature programming or the necessity of maintaining temperatures below the ambient.

Our experiences with series columns had not been particularly successful, but the experiments with the *mixed* columns, using the same preparations of packing materials and identical packing procedures, were so fruitful that we thought it worth while directing attention to what was, to us at least, a new technique.

J. A. BARNARD
H. W. D. HUGHES

Department of Chemical Engineering,
University College,
London.

Structure of 'Cystine Disulphoxide'

ALTHOUGH the reactions of aromatic 'disulphoxides' have been studied by Smiles and his co-workers[1] and by Vinkler and Klivenyi[1] among others, the structures of these compounds remained uncertain until their infra-red spectra were examined by Cymerman and Willis[3]. The latter work confirmed earlier evidence that the compounds hitherto known as disulphoxides should be assigned the thiolsulphonate structure (I) rather than the disulphoxide structure (II).

$R—SO_2—S—R$ (I) $R—SO—SO—R$ (II)

Grushko and Guryanova[4] have recently made a study of some aliphatic analogues and conclude that they also have structures of type (I). The best-known aliphatic 'disulphoxide' appears to be that from cystine and this compound was assigned a structure of type (II) on chemical evidence[5], a structure which is still current in recent biochemical literature[6]. In connexion with other work we have obtained the infra-red spectrum of this compound and find it to have the characteristics of a thiolsulphonate rather than a disulphoxide. The strong bands at 1,110 cm.$^{-1}$ and 1,300 cm.$^{-1}$ agree well with those given by aromatic thiolsulphonates[3,7] and the spectrum showed no strong band near 1,050 cm.$^{-1}$ as exhibited by sulphoxides.

Using structure (II) Toennies and Lavine[5] found it necessary to introduce a series of intermediates to explain the reactions of 'cystine disulphoxide', but it is evident that these reactions can be more readily explained on the basis of structure (I). For example, 'cystine disulphoxide' reacts with cysteine to give cystine and cysteine sulphinic acid[6], and we have followed the course of this reaction by means of circular paper chromatography using *tert*-butanol – formic acid – water as solvent and ninhydrin in dry acetone as detecting agent. In our experiments the only bands appearing had R_F values of 0·04 and 0·20 (both due to cystine) and 0·35 (cysteine sulphinic acid). Examination of scale models suggests attack at the hexavalent sulphur to be sterically hindered, and in this reaction nucleophilic attack by the thiol group of cysteine might then be expected to occur at the adjacent sulphur atom, followed by fission of the SO_2—S bond of the thiolsulphonate and transfer of hydrogen. Other reactions of the thiolsulphonate can mostly be explained in a similar manner.

B. J. SWEETMAN

Chemistry Department,
University of Otago,
Dunedin.

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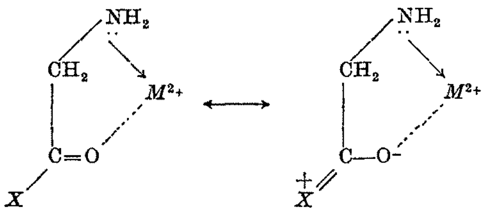
BIOCHEMISTRY

Relationship between Proton and Metal Binding by some Peptides, Amino-acid Amides and Amino-acids

THE stability constants of a series of ligands of the type, $NH_2.CH_2.CO.X$, with the ions Cu(II), Co(II) and Mn(II), have been measured in this laboratory[1], and it has been shown that, for any one of the metals, a linear relationship exists between log K_1 (first stability constant) and pK_a (acid dissociation constant of the amino-group)[2]. The group X can have a variety of structures ranging from O^- (glycine) to NH_2 and $NH.CH_2.COO^-$ (glycinamide and glycylglycine). From these observations it was concluded that the structure of the metal complexes was best represented thus:



For Cu(II) this structure only applies to the complexes initially formed, prior to the onset of additional acid dissociations which occur for some of the ligands.

The structure of peptide – metal complexes is of considerable importance in understanding the mode of action of proteolytic enzymes, and it is evident that additional experimental work is urgently required in this field. The formulation given above is consistent with infra-red measurements on urea complexes[3], but the only evidence for it is indirect and based on the observed relationships between log K_1 and pK_a. Since these types of correlation can, in some circumstances, be fortuitous[4], it was considered necessary to see if similar relationships occurred in other related series of ligands.

The results obtained for a series of sarcosyl ligands, $CH_3.NH.CH_2.CO.X$, are shown in Fig. 1. It can be seen that a linear relationship exists between log K_1

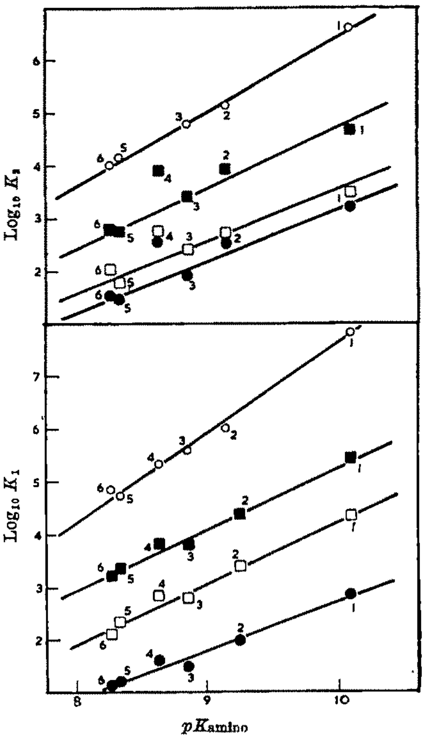


Fig. 1. Plots of log K_1 and log K_2 against pK_a for a series of sarcosyl compounds. ○, Cu(II); ■, Ni(II); □, Co(II); ●, Cd(II) (log K_1 − 1). 1, Sarcosine; 2, sarcosylsarcosine; 3, sarcosine dimethylamide; 4, sarcosyl L-leucine; 5, sarcosine amide; 6, sarcosine methylamide

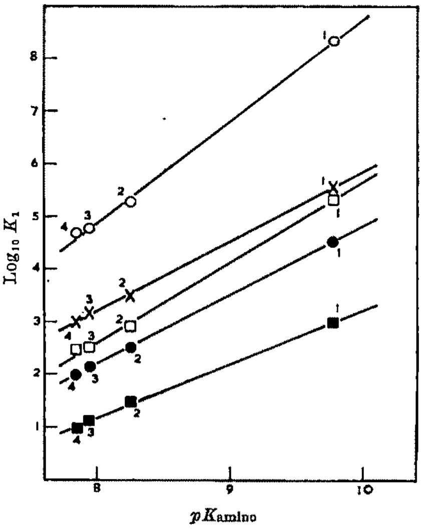


Fig. 2. Plots of log K_1 against pK_a for a series of leucyl compounds. ○, Cu(II); ×, Ni(II); □, Zn(II); ●, Co(II); ■, Cd(II) (log K_1 − 1). 1, Leucine; 2, leucylglycine; 3, leucylglycylglycine; 4, leucine amide

and pK_a for Cu(II), Ni(II), Co(II) and Cd(II); none of the constants shows significant deviation from the regression line. Similar straight-line correlations of log K_2 (second stability constant) and pK_a for the sarcosyl ligands are observed, with the single exception of sarcosyl L-leucine. A series of leucyl compounds have also been investigated and the results are illustrated in Fig. 2; these ligands show excellent straight-line correlations of log K_1 and pK_a for the complexes of Cu(II), Ni(II), Zn(II), Co(II), and Cd(II). It can safely be concluded that these linear relationships are not fortuitous, and they provide further evidence that the structures of the metal complexes of peptides and amino-acid amides are as shown above. It should be noted that, for any metal ion, a linear relationship between log K_1 and pK_a for a series consisting of all the glycyl, sarcosyl and leucyl compounds does not exist, nor is it expected. This suggests that the correlations observed for the individual series have physical significance.

The second stability constants of sarcosyl L-leucine with Ni(II), Co(II) and Cd(II) are too high to fall on the regression line of the other sarcosyl compounds. Presumably a stabilizing influence is present in the sarcosyl L-leucine 2 : 1 complexes which is absent in the other ligands and in the sarcosyl L-leucine 1 : 1 complexes. Sarcosyl L-leucine differs from the other ligands in possessing a large aliphatic side-chain; it is possible that the abnormally high stability of the 2 : 1 complexes of this compound is due to Van der Waals interactions between the side-chains of the pair of ligands co-ordinated to the metal. If so, the difference between the observed and predicted values of log K_2 gives a measure of the free-energy change associated with this interaction in aqueous solution; further investigations of this problem are intended.

S. P. DATTA
R. LEBERMAN
B. R. RABIN

Department of Biochemistry,
University College, London,
Gower Street,
London, W.C.1.

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Multiplicity of Histidine–Cu(II) Complexes

THE stability constants of the histidine complexes of several metals have been determined by several workers[1-4]. Satisfactory values of the stability constants can be calculated from titration data for all the metals investigated except Cu(II). Albert[3] suggested that the anomalies in the histidine – Cu(II) system are due to the planar configuration of cupric complexes in solution, which makes it impossible for all the three sites available for co-ordination (amino, imidazole and carboxyl) to be bound simultaneously to the metal ion. It has been shown[5] that other anomalies also occur in the co-ordination of Cu(II) by histidine.

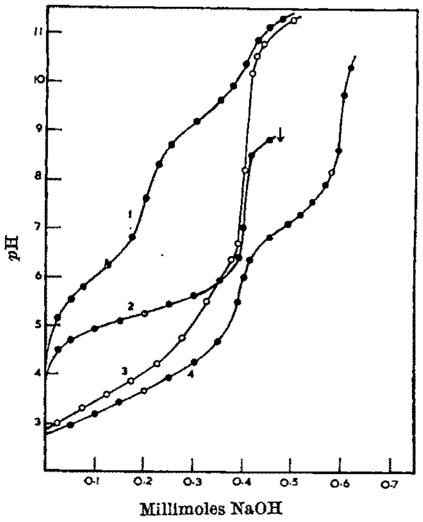


Fig. 1. Titration curves of histidine hydrochloride (0·2 m*M*) with sodium hydroxide (0·1 *N*): 1, no additions; 2, plus 0·2 m*M* cobalt chloride (for comparison); 3, plus 0·1 m*M* cupric chloride; 4, plus 0·2 m*M* cupric chloride

If the titration curves of histidine hydrochloride in the absence and presence of equimolar cupric chloride are compared (Fig. 1), it can be seen that the presence of Cu(II) produces one additional equivalent of acid. When the ligand – Cu(II) ratio is 2 : 1, the amount of base required to titrate all the acid species is the same as in the absence of metal. This means that an acid dissociation occurs from the 1 : 1 complex which is suppressed when the ligand to metal ratio is 2 : 1. These observations suggest that the additional acid ionization occurs from a water molecule co-ordinated to the copper atom of the 1 : 1 complex.

Attempts were made to calculate the stability constants on the assumption that the following equilibria were involved:

For 1 : 1 mixtures, $Cu^{2+} + L^- \overset{K_1}{\rightleftharpoons} CuL^+$ (1)

$$CuL^+ \overset{K_{c'}}{\rightleftharpoons} CuL + H^+ \qquad (2)$$

For 2 : 1 mixtures, $Cu^{2+} + L^- \overset{K_1}{\rightleftharpoons} CuL^+$ (1)

$$CuL^+ + L^- \overset{K_2}{\rightleftharpoons} CuL_2 \qquad (3)$$

$$\text{where } K_1 = \frac{[CuL^+]}{[Cu^{2+}][L^-]};\ K_2 = \frac{[CuL_2]}{[CuL^+][L^-]};\ K_{c'} = \frac{[CuL][H^+]}{[CuL^+]}$$

Satisfactory values of K_1 and K_2 could not be computed on these assumptions. Mixtures of histamine and cupric chloride showed the same phenomena on titration, but in this instance consistent values of K_1, K_2 and $K_{c'}$ could be obtained (log K_1 = 9·44, log K_2 = 6·39, $pK_{c'}$ = 7·00). Thus the difficulties in calculating the stability constants of the cupric complexes of histidine are not due to reaction (2).

If the interactions of histidine with Cu(II) only occur at any pair of the three available binding sites, singly protonated histidine (L^{+-}) can also act as a chelating species; then the structure of the 1 : 1 complex will vary with pH and the following equilibria must be considered when the ligand to metal ratio is 1 : 1:

$$Cu^{2+} + L^{+-} \overset{K_1}{\rightleftharpoons} CuL^{2+} \qquad (4)$$

$$CuL^{2+} \overset{K_c}{\rightleftharpoons} CuL^{+} + H^{+} \qquad (5)$$

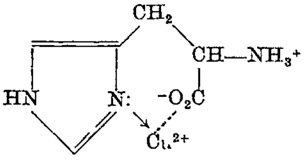
$$Cu^{2+} + L^{-} \overset{K_1}{\rightleftharpoons} CuL^{+} \qquad (1)$$

$$CuL^{+} \overset{K_c'}{\rightleftharpoons} CuL + H^{+} \qquad (2)$$

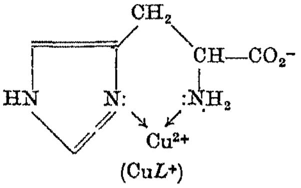
$$\text{where } K_1' = \frac{[CuL^{2+}]}{[Cu^{2+}][L^{+-}]} \text{ and } K_c = \frac{[CuL^{+}][H^{+}]}{[CuL^{2+}]}.$$

Quantitative analysis in terms of this reaction scheme yields consistent values of the equilibrium constants. The method of calculation was similar to that used for the glycylglycine – Cu(II) system[6] and will be reported in detail elsewhere. The following values were obtained: $\log K_1 = 10 \cdot 37$, $\log K_1' = 5 \cdot 02$, $pK_c = 3 \cdot 81$ and $pK_c' = 7 \cdot 19$.

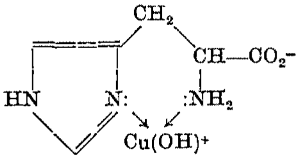
The most probable structures of the 1 : 1 complexes are:



(CuL^{2+})



(CuL^{+})



(CuL)

In the formation of histidine – Cu(II) 2 : 1 complexes, either of or both the ligand-chelating species (L,L^-) can be involved in interactions with CuL^{2+} and CuL^{+}. Thus there are three possible 2 : 1 complexes and the evaluation of the constants from titration data is extremely difficult.

We thank Dr. S. P. Datta for many valuable suggestions during the course of this work.

R. Leberman
B. R. Rabin

Department of Biochemistry,
University College, London,
Gower Street, London, W.C.1.

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Feedback Control of Purine Biosynthesis by Purine Ribonucleotides

In recent years a number of biosynthetic sequences have been shown to be regulated by feedback mechanisms, which have been of two general types, the first involving regulation of the activity of an enzyme by an inhibitory effect of an end-product[1,2], the second involving regulation of the rate of synthesis of an enzyme by negative-induction, or suppression, of synthesis by an end-product[3,4]. In both types of mechanisms the inhibition involves the earliest step leading specifically to the synthesis of the regulating compound, which is itself a product normally present in the cell in appreciable concentration[1,2].

The existence of feedback control mechanisms in purine biosynthesis has been suggested by a number of observations, summarized elsewhere[5,6]. In these studies the presence of unlabelled purines suppressed *de novo* purine synthesis from labelled precursors. In no instance, however, was a precise characterization or localization of the control mechanism demonstrated.

In the biosynthesis of purines the first irreversible and specific step is that in which β-phosphoribosylamine is generated from α-phosphoribosylpyrophosphate and glutamine[7–9]:

$$\alpha\text{-phosphoribosylpyrophosphate} + \text{glutamine} + \text{water} \xrightarrow{Mg^{2+}} \beta\text{-phosphoribosylamine} + \text{glutamic acid} + \text{pyrophosphate}$$

The enzyme catalysing this reaction, phosphoribosylpyrophosphate amidotransferase[9], would appear to be a likely site for the operation of a feedback control.

We have purified α-phosphoribosylpyrophosphate-amidotransferase from the supernatant fraction of pigeon liver, by fractionation with ammonium sulphate, differential heat inactivation[9], and adsorption on to, and elution from, aged calcium phosphate gel. The reaction was followed kinetically by observing the rate of generation of glutamate, measured as reduction of the 3-acetyl pyridine analogue of diphosphopyridine nucleotide, in the presence of glutamic dehydrogenase[10], in 0·05 *M tris*(hydroxymethyl) aminomethane buffer, *p*H 8·0.

Evidence was secured for non-consecutive binding of α-phosphoribosylpyrophosphate and glutamine at independent binding sites. When concentrations of the former and of glutamine were varied independently at four levels each, and the velocity data plotted according to Frieden[11], the lines converged to a single

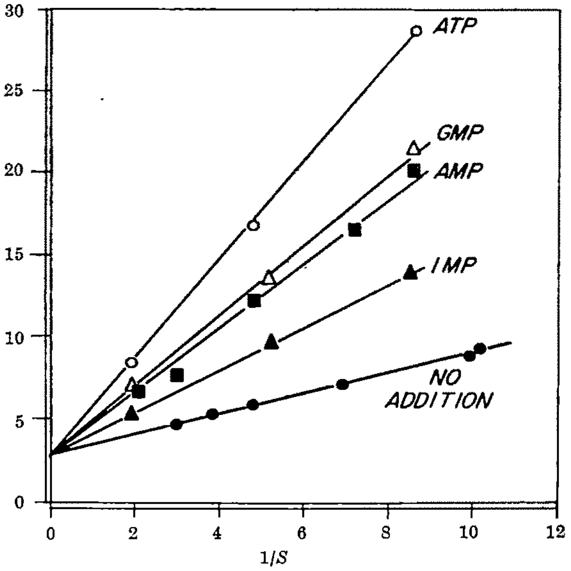

Fig. 1. Dependence of reaction velocity upon concentration of α-phosphoribosylpyrophosphate, and effect of inhibitors. Velocity was measured as increase in absorbance at 363 mμ per 10 min.; substrate in μmoles per ml. In all cases inhibitors were added in final concentration of 0·2 μmole per ml. Reactions were followed according to the standard assay, at room temperature, in 1-ml. quartz cells having a light path of 1 cm.

intercept on the extended X-axis in each case; that is, when S = α-phosphoribosylpyrophosphate, at various glutamine-levels, and when S = glutamine, at various levels of α-phosphoribosylpyrophosphate. The K_m for α-phosphoribosylpyrophosphate was $2 \cdot 3 \times 10^{-4}$ M and for glutamine was $1 \cdot 1 \times 10^{-3}$ M.

Many naturally occurring compounds were studied as potential feedback inhibitors of this enzyme. Inhibition was observed with 5-amino-4-imidazolecarboxamide ribonucleotide, inosine monophosphate, adenosine mono-, di- and tri-phosphates and guanosine mono- and di-phosphate. Selected results, plotted in Fig. 1, show competitive inhibition by inosine monophosphate, adenosine monophosphate, guanosine monophosphate and adenosine triphosphate of binding of α-phosphoribosylpyrophosphate by the enzyme. Average values for the dissociation constants of inhibitors are shown in Table 1. In other studies, the inhibitions were shown to be non-competitive with respect to binding of glutamine.

Table 1. MICHAELIS–MENTEN CONSTANTS OF SUBSTRATES AND DISSOCIATION CONSTANTS OF INHIBITORS

Substrate	K_m
Phosphoribosylpyrophosphate	$2 \cdot 3 \times 10^{-4}$ M
Glutamine	$1 \cdot 1 \times 10^{-3}$ M
Inhibitor	K_i
Adenosine triphosphate	$3 \cdot 7 \times 10^{-5}$ M
Adenosine diphosphate	$3 \cdot 9 \times 10^{-5}$ M
Guanosine monophosphate	$8 \cdot 6 \times 10^{-5}$ M
Adenosine monophosphate	$9 \cdot 0 \times 10^{-5}$ M
Inosine monophosphate	$1 \cdot 8 \times 10^{-4}$ M
Guanosine diphosphate	$3 \cdot 8 \times 10^{-4}$ M

Several related compounds were shown not to inhibit this enzyme. They included deoxy-adenosine monophosphate, deoxy-guanosine monophosphate, adenosine monophosphate-2′,-3′, inosine di- and triphosphate, guanosine triphosphate and ribose 5-phosphate, as well as purine bases and ribonucleosides and pyrimidine ribonucleoside monophosphates and triphosphates, and inorganic pyrophosphate. Thus, the inhibitory effects described would appear to be rather specific for certain purine ribonucleotides, of which adenosine di- and tri-phosphates are the most potent.

The regulation of activity of the amidotransferase by purine ribonucleotide products offers a mechanism for control of purine biosynthesis capable of responding rapidly to environmental changes. Such a control mechanism would account for the orderly synthesis of purine ribonucleotides and the maintenance of relative constancy of concentrations of purine ribonucleotides within the cell.

JAMES B. WYNGAARDEN
DORIS M. ASHTON

Department of Medicine,
Duke University Medical Center,
Durham, North Carolina.
Dec. 22.

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Effect of Substitution in the Side-Chain on β-Oxidation of Aryloxy-alkylcarboxylic Acids by *Nocardia opaca*

THE rate of β-oxidation of γ-substituted butyric acids by washed suspensions of species of soil *Nocardia* has been found to depend on the nature of the substituents[1,2]. γ-Phenoxybutyric is oxidized more slowly than γ-phenylbutyric acid, and substitution in the phenoxy group, particularly in the *ortho* position, further retards the process. β-Hydroxy acid intermediates were generally formed from γ-aryloxybutyric acids. It has now been found that the substitution of CH_3— for H— on the γ carbon atom of the γ-phenoxybutyric acids further retards β-oxidation.

In this work washed suspensions of *Nocardia opaca* (strain T_{16}), and the techniques of paper chromatography and infra-red analysis previously described[1] were used to study the conversion of DLγ-phenoxy-γ-methylbutyric, DLα-(4-chloro-2-methylphenoxy)-α-methylacetic, DLγ-(4-chloro-2-methylphenoxy)-γ-methylbutyric and DLε-(4-chloro-2-methylphenoxy)-ε-methylcaproic acids. We are indebted to Dr. B. J. Heywood of May and Baker, Ltd., for generous supplies of the first three compounds. DLε-(4-chloro-2-methylphenoxy)-ε-methylcaproic acid was prepared from DLγ-(4-chloro-2-methylphenoxy)-γ-methylbutyric acid by reduction to the alcohol (b.p. 146° C. at 0·1 mm.) with lithium aluminium hydride and formation of the bromide (b.p. 127° at 0·4 mm.) with phosphorus tribromide followed by condensation with malonic ester (in butanol). The dibutyl ester obtained decomposed to some extent on distillation, and the crude DLε-(4-chloro-2-methylphenoxy)-ε-methylcaproic acid obtained by hydrolysis and decarboxylation in the usual way was purified by conversion to the ethyl ester (b.p. 140° at 0·3 mm.) which was distilled and saponified. The syrupy product (found C, 61·35; H, 6·86, $C_{14}H_{19}O_3Cl$ requires C, 62·02; H, 7·05 per cent) gave only a single spot on the paper chromatogram, but this was not well separated from DLγ - (4 - chloro-2 - methylphenoxy)-γ - methylbutyric acid.

Table 1 indicates that DLγ-phenoxy-γ-methylbutyric acid is metabolized at a slower rate than γ-phenoxybutyric acid, when these substances are exposed to suspensions of T_{16} in the Warburg flask.

Table 1

Substrate	μlitres oxygen/3 hr.
None	55·7
M/250 γ-phenoxybutyric acid	123·3
M/250 γ-phenoxy-γ-methylbutyric acid	86·9

Each vessel contained 1·0 ml. cell suspension (10·6 mgm./ml. dry wt.) + 0·5 ml. M/15 phosphate buffer pH 7·2 + 0·5 ml. substrate (as sodium salt) + water to give a final volume of 2·5 ml. The centre well had 0·2 ml. 5 per cent potassium hydroxide.

Confirmation of this was obtained in a large-scale experiment in which cells were incubated with these compounds. Paper chromatography of ether extracts of suitable aliquots showed that whereas γ-phenoxybutyric acid had been completely converted in 3 days, only about 60 per cent of DLγ-phenoxy-γ-methylbutyric acid had been converted. Infra-red analysis of the final products confirmed that γ-phenoxybutyric acid had been completely converted to phenoxyacetic acid, which was isolated in crystalline form, but that 50 per cent of the product from γ-phenoxy-γ-methylbutyric acid consisted of the β-hydroxy acid. A small amount of phenoxy-α-methylacetic acid was also present. After a further addition of cells comte oxidation to the acetic acid was achieved, wing that both D- and L-isomers had been meta-ized.

A large-scale experiment was also set up to study behaviour of DLα-(4-chloro-2-methylphenoxy)-α-thylacetic acid and DLγ-(4-chloro-2-methylphen-γ)-γ-methylbutyric acid. After six fresh additions washed cells at 7-day intervals it was found that substantial change had occurred in either. evious work[1] with γ-(4-chloro-2-methylphenoxy) tyric acid under these conditions showed conver-n to the corresponding β-hydroxy acid. The fore-ing experiments clearly demonstrate that the com-unds with the unbranched side-chain are much re easily oxidized than those with a branched side-ain.

This effect, as with ring substitution[1], is most arked with a short fatty acid side-chain. Thus it found in Warburg experiments that there was a l increase in oxygen uptake by cells of T_{16} DLε-(4-chloro-2-methylphenoxy)-ε-methylcap-l when compared with DLγ-(4-chloro-2-noxy)-γ-methylbutyric acid suggesting a rapid breakdown of the side-chain of the s was confirmed in a large-scale incubation where it was shown by infra-red analysis -chloro-2-methylphenoxy)-ε-methylcap-d been converted to DLγ-(4-chloro-2-xy)-γ-methylbutyric acid in 4 days. crystalline product was isolated.

these results suggest that many plants ze γ-(4-chloro-2-methylphenoxy) butyric il to convert DLγ-(4-chloro-2-methyl-nethylbutyric acid to the herbicidal -2-methylphenoxy)-α-methylacetic acid[3].

D. M. WEBLEY
R. B. DUFF
V. C. FARMER

Institute for Soil Research
Craigiebuckler,
Aberdeen.
Jan. 9.

D. M., Duff, R. B., and Farmer, V. C., *J. Gen. Microbiol.*, 733 (1958).

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Crystallization of Gramicidin

GRAMICIDIN, an antibiotic produced from a strain of *Bacillus brevis*, is reported to be soluble in the lower alcohols and to be crystallizable from dioxan and/or acetone[1-3]. With some special batches of gramicidin, Synge[4] has obtained a few crystals from ethanol after slow vapourization of the solvent.

In all manuals a melting point of 228–231° C. is quoted for crystalline gramicidin.

All batches of gramicidin so far tested by us have yielded crystals from ethanol not only after vapourization of the solvent but also on prolonged standing at room temperature.

X-ray diffraction studies of this product and of that crystallized from acetone revealed essentially the same basic picture. However, the diffraction pattern of the former was much easier to see, disclosing a larger number of lines and thus indicating better structure of crystals obtained from ethanol (Table 1).

Table 1

Line No.	Acetone form		Ethanol form	
	Distance (cm.)	Description	Distance (cm.)	Description
1–2	1·3–1·5	diffuse band	1·3 1·5	strong line strong line
3	1·9	very faint diffuse line	1·9	diffuse line
4		?	2·25	faint double line
5		?	2·8	faint diffuse line
6		?		?
7	3·3	diffuse band	3·4	strong line
8		diffuse band	3·65	strong line
9	3·95	diffuse band	3·95	strong line
10		?	4·1	faint line
11	4·3	double line	4·3	strong line
12	4·5	faint (double ?) line	4·6	faint line
13	4·75	double line	4·8	double line
14		?	4·95	faint line
15		?	5·28	very faint line
16		?	5·98	faint diffuse line
17		?	6·25	very faint line
18		?	6·5	very faint line
19		?	6·93	very faint line
20	7·25	faint line	7·2	very faint line
21		?	7·7	faint line
22	8·15	faint line	8·15	very faint line
23		?	8·7	very faint line
24		?	10·6	faint double line
25		?	12·1	very faint line
26		?	13·1	faint line

Further investigations revealed distinct differences in solubilities and melting points of the two 'gramicidin forms'. To obtain additional information, we have re-crystallized the 'acetone form' from a number of solvents. Some characteristics of the most thoroughly investigated products are listed in Table 2.

The solubility of four 'gramicidin forms' in 96 per cent ethanol was investigated at different temperatures (Fig. 1). In order to avoid too much interference by transformation processes in all these investigations, a short equilibration period (1-hr. shaking) had to be used. Even under such conditions, it was difficult to obtain consistent results—especially with different batches.

Recrystallization was also carried out with mixtures of solvents. The melting point followed that obtainable with the solvent last vapourized in the process.

The conclusion seems to be that the solvent used for the crystallization, or the solvent persisting longest during the process of drying, determines the melting point and the solubility of the final product. It is our impression that in the case of crystallization from acetone a considerable number of solvent molecules are embedded into the crystalline structure but removed upon drying. This is indicated both by the voluminous consistency in acetone of the slurry and the moist cake—not observed in the case of crystallization from alcohols, higher ketones, ether or cyclic solvents—and the marked influence of the drying conditions upon the melting point. Also the inferior crystalline structure and lower melting point

Table 2

Recrystallized from	Solubility at room temperature		Melting point, corrected (° C.)
	In ethanol	In methanol	
Acetone	21·0%	>25·0%	228–231* 232–235*
Methanol	3·5%	3·9%	244–247
Ethanol	3·3%	>25·0	247–249†
n-Butanol	2·4%	39·0%	246–248

* Depends on the drying conditions, the higher melting-point range being obtained in a very slow drying process.

† Recently we have obtained a melting point of 251–253° C. (corr.) with a batch recrystallized several times from ethanol.

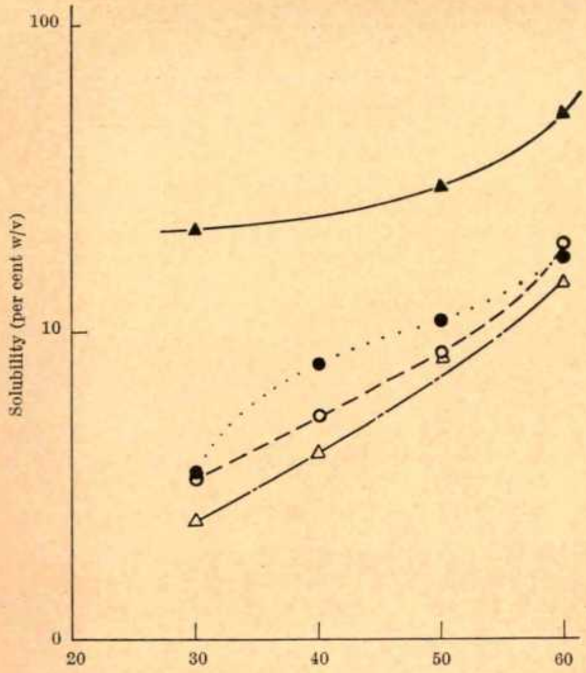

Fig. 1. ▲, Acetone form; ●, methanol form; ○, ethanol form; △, *n*-butanol form

indicate a kind of deterioration of the structure which might be due to the removal of acetone. This seems to confirm Hodgkin's[5] hypothesis, at least in the case of acetone.

The different 'forms' of gramicidin may, under proper conditions, be quantitatively (on weight as well as biopotency basis) transformed into each other.

We are indebted to Dr. M. Danø, Department of Mineralogy, University of Copenhagen, for the X-ray analysis.

P. E. OLESEN
L. SZABO

Microbiological Department,
H. Lundbeck and Co. Inc.,
7, Ottiliavej,
Copenhagen–Valby.
Dec. 30.

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ANIMAL PHYSIOLOGY

Ganglionic Block and Monoamine Oxidase Inhibitors

RECENTLY, certain monoamine oxidase inhibitors have been reported to be useful in the treatment of hypertension, and some of the clinical data suggest that ganglionic blockade may be caused by such agents[1,2]. To date, however, there have been no pharmacological studies to support these clinical impressions. In re-examining data, presented by Gertner, Paasonen and Giarman[3], demonstrating the presence of 5-hydroxytryptamine when the superior cervical ganglion was perfused with iproniazid, it w seen in these experiments that iproniazid block ganglionic transmission. Furthermore, a defin dosage–response relationship was found; minin blocking effects were seen with 100 μgm. of iproniaz per ml. of perfusion fluid and complete blockade wh 400 μgm./ml. was used. The appearance of 5-hydrox tryptamine in the perfusate occurred a consideral time after the appearance of ganglionic blockade. ascertaining the effects of the *p*-tolyl ether of cholir the authors found that it, too, would block trar mission, but no 5-hydroxytryptamine appeared the perfusate.

Recently, in examining two additional pote monoamine oxidase inhibitors, β-phenyl *iso*propy hydrazine (*JB*–516, Lakeside Laboratories)[4] and t alkaloid harmine[5], it was found that both these agen blocked transmission, in a manner similar to ipr niazid. When the ganglion was perfused wit Locke's solution containing 10 μgm./ml. of β- *iso*propylhydrazine, a gradual block of trans resulted, which increased in magnitude over [illegible] of 1 hr. This block could be reversed by [illegible] to drug-free Locke's solution. β-Phenyl [illegible] hydrazine at 20 μgm./ml. produced a mor [illegible] greater block of transmission, and in [illegible] concentration to 50 μgm./ml. resulted [illegible] and immediate blockade, which was g [illegible] partially reversible if the ganglion was [illegible] this substance for periods of an hour. [illegible] concentrations of 10 μgm./ml. produce [illegible] transmission which was similar to th [illegible] β-phenyl *iso*propylhydrazine. This effect [illegible] over a period of 1 hr. and completely rev [illegible] increasing the concentration of harmine t [illegible] a complete block was observed in 15 min. [illegible] entirely reversible. In all these experim [illegible] of the perfusion fluid was very carefully [illegible] 7·3.

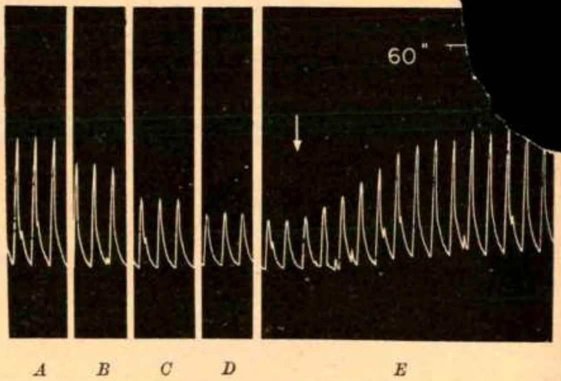

Fig. 1. Effect of harmine on the superior cervical ganglion of the cat. Contractions of the nictitating membrane to stimulation of the cervical sympathetic trunk at 0·5 m.sec., 10 c.p.s. and maximal voltage (*A*); control (*B*); 15 min. after start of perfusion with harmine, 10 μgm./ml. (*C*); 30 min. later (*D*); 1 hr. later (*E*). At arrow Locke's solution lacking the inhibitor was re-instituted

β-Phenyl *iso*propylhydrazine is a substance similar in structure to iproniazid. The action of this compound in blocking transmission would therefore appear to be analogous to the action of iproniazid, another hydrazine. Isoniazid, however, another hydrazine derivative, which lacks the ability to inhibit monoamine oxidase[6], was found to be without action on the ganglion in concentrations up to 400 μgm./ml. Harmine is of a completely different cæmia[9] in which there is a deficiency of an essential substrate for the brain. The results of this study resemble those of insulin hypoglycæmia, and suggest that perhaps with pyridoxine deficiency also there is interference with the supply or utilization of an essential substrate for the brain.

The convulsions caused by pyridoxine antagonists in experimental animals have been found to be associated with a decreased level of γ-amino-butyric acid in the brain and to be arrested by administration of this compound[2]. γ-Amino-butyric acid is formed only in the central nervous system by the decarboxylation of glutamate, which is dependent on pyridoxal phosphate, but there is some uncertainty whether it functions in the brain as a neurohumoral mediator of cerebral inhibitory functions or as a substrate for metabolic oxidations[1,10]. In the former case, its deficiency might be expected to lead to convulsions with increased consumption of cerebral oxygen because of increased neuronal functional activity; in the latter, reduction in cerebral metabolic rate would be expected. The results of this study tend to support the latter hypothesis.

LOUIS SOKOLOFF
NIELS A. LASSEN

Laboratory of Clinical Science,
National Institute of Mental Health.

GUY M. MCKHANN
DONALD B. TOWER

Section on Clinical Neurochemistry,
National Institute of Neurological
Diseases and Blindness.

WAYNE ALBERS

Laboratory of Neuroanatomical Sciences,
National Institute of Neurological
Diseases and Blindness,
National Institutes of Health,
Bethesda 14, Maryland.
Dec. 30.

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Arginine Esterase Activity of 'Blood Thromboplastin'

THE presence of a thromboplastin-generating system in blood has been shown by Biggs, Douglas and Macfarlane[1]. It is now recognized that at least six different factors participate in the formation of 'blood thromboplastin' and that a series of reactions resulting in the production of hypothetical intermediates such as product I and product II (Table 1) precede the appearance of the active prothrombin-converting substance[2,3].

Table 1

System	Tosyl – arginine methyl ester esterase activity
Product I	
Aged plasma treated with barium sulphate	
Serum	
Calcium chloride	
Buffer	52
Product II	
Product I	
Azolectin	71
'Blood thromboplastin'	
Product II	
Purified human plasma *Ac–G*	107

Plasma and serum components were prepared from fresh normal human blood. '*Ac–G*-free' plasma was prepared by incubating plasma for 24 hr. at 37° C. This plasma was treated with barium sulphate until it had a prothrombin time of at least 60 min. The serum was incubated at 37° C. until it did not produce a fibrin strand for 60 min. when added to purified bovine fibrinogen. A 30-mgm. per cent aqueous emulsion of azolectin (soybean phosphatides) served as a platelet substitute. Purified human plasma *Ac–G* was prepared according to Lewis and Ware (ref. 4). Suitable dilutions of the various components were made with 0·025 *M tris* buffer, *p*H 8·2. Pre-incubation of the generating systems was allowed to proceed for 6 min. at 37° C. Tosyl – arginine methyl ester esterase activity levels were determined for a 90-min. period at 37° C. using a modification of the method of Rhodes, Hill and Feeney (ref. 5).

We have found that complete thromboplastin-generating systems prepared with normal human plasma and serum components exhibit tosyl–arginine methyl ester esterase characteristics and that similar, although less marked, activities were also shown by product I and product II mixtures (Table 1). Although special precautions were taken in this work to ensure the absence of prothrombin and thrombin in both plasma and serum components of the thromboplastin-generating mixture, the possibility that a small amount of thrombin was formed during the pre-incubation of the complete system cannot be excluded.

The addition of soybean trypsin inhibitor to the complete thromboplastin-generating system following its pre-incubation resulted in marked inhibition of its tosyl–arginine methyl ester esterase activity. Essentially identical results were also obtained when the thromboplastin-generating system was made up with plasma and serum components from patients maintained on long-term prothrombin-depressant anticoagulant therapy. When, on the other hand, plasma and serum components from patients with histories of thrombo-embolic episodes were used the esterase activity still measurable in the presence of soybean trypsin inhibitor is more than twice that found with the other two groups (Table 2).

Soybean trypsin inhibitor does not interfere with the clotting activity of purified thrombin and we have

Table 2

Type of patient	Tosyl – arginine methyl ester esterase activity of 'blood thromboplastin'	Tosyl – arginine methyl ester esterase activity of 'blood thromboplastin' in presence of SBTI*
'Normal'	89 (70–127)	14 (0–36)
Long-term anticoagulant therapy	74 (53–90)	8 (0–12)
Past history of thrombo-embolism	111 (52–173)	43 (22–69)

* Soybean trypsin inhibitor

The figures represent the averages of the results obtained with six different patients in each of the three groups, and the figures in the brackets show the range of the individual determinations. Soybean trypsin inhibitor was added to the system following the 6-min. pre-incubation period to give a final concentration of 60/μgm./ml. Other details of the procedure were the same as those described in the legend for Table 1.

observed a similar lack of inhibition of the activity of its tosyl–arginine methyl ester esterase. Whether or not the thromboplastin esterase activity still measured in the presence of the inhibitor is actually due to thrombin is not known at present, although the clotting of purified fibrinogen by the complete thromboplastin-generating system suggests that this may, in fact, be the case. Evidence for the formation of trace amounts of thrombin in a similar pre-incubation system has been presented by Johnston and Jensen[6].

The findings reported here are of particular interest in view of some recent observations on differences in activities of tosyl–arginine methyl esterase of freshly collected, citrated plasmas of the same three groups of patients[7]. The possible relationship between the two sets of observations is now being studied and will be reported in greater detail elsewhere.

This work was supported by the Medical Research and Development Board, Office of the Surgeon General, Department of the Army, under Contract No. *DA*-49-007-*MD*-275.

PHYLLIS M. ARSCOTT
J. L. KOPPEL
JOHN H. OLWIN

Coagulation Laboratory,
Department of Surgery,
Presbyterian–St. Luke's Hospital,
College of Medicine,
University of Illinois,
Chicago.
Dec. 16.

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Aortic Medial Calcification and Lowered Metabolism in Ground Squirrels

THIS study was intended to test in mammals the concept that some animals have a potential physiological limit of energy which may be utilized at different rates depending upon environmental temperatures. McArthur and Baillie[1] were able to triple the life-span of *Daphnia* (Crustacea) by a 20-deg. drop in temperature. The total heart beats during the life of the *Daphnia* differed by less than 2 per cent whether the duration of life was a few days due to high temperature or several months due to low temperature. Similarly, Carlson and Hoelzel[2] prolonged the life-span of white rats by reducing their metabolism by partial starvation.

In our investigation, two groups of thirteen-lined ground squirrels: a control group (N-14) always maintained at room temperature, and a group which hibernated (N-15 → 12) for 4 months each of three winters under controlled conditions (12 months of hibernation). All animals (with one accidental exception) were born in the laboratory, and each litter was divided between control and experimental groups. Each hibernator when in the cold showed bouts of deep hibernation for about 6 days at a time in the classic state of very reduced body temperature, heart-rate, breathing-rate and metabolism. The periodical awakening lasted about 12–24 hr. Observation methods and results have been detailed elsewhere[3,4]. During the second winter of hibernation one hibernator died and two others died during their usual summer stay in the warm room, which had heated up briefly to more than 32° C. due to a spell of hot weather. Since no control ground squirrels died of natural causes, we may speculate that for some ground squirrels hibernation may be directly or indirectly a stress. At the end of the hibernation period of the third winter, when the specimens were 3 years old, physiological measurements were made at room temperature on 12 hibernators and on the 14 control squirrels. Then both groups were killed, and a series of biochemical and morphological tests were made. At this time the squirrels should be considered at least middle-aged although the life-span of the thirteen-lined ground squirrel has not been determined. 13 of the series (5 hibernators and 8 non-hibernators) were examined histologically. The results were checked against 53 recently caught wild ground squirrels. The rest of this report will concern only the blood vessel findings in the histological observations. Some of the other results have been reported earlier[3,4].

Table 1. DISTRIBUTION OF AORTIC MEDIAL CALCIFICATION IN GROUND SQUIRRELS RAISED IN LABORATORY (N = 13)

Aortic calcification	No calcification
Hibernators:	
Male*	Male (*a*)
	Female (*a*)
	Female
	Female
Non-hibernators:	
Female (*a*)†	Male
Male	Male (*b*)
Female	Female (*b*)
Female	Female

* More than four years old (trapped as adult); all others are three years old (born in laboratory).
† Letters, if present, identify litter mates.

Calcified plaques were observed in the media of the aorta in 5 ground squirrels (see Table 1). The lesions were histologically indistinguishable from human vascular medial calcification (also referred to as Mönckeberg's sclerosis or senile arteriosclerosis). The anatomical location, however, differed. In ground squirrels the lesion was found only in the proximal aorta (absent in the abdominal aorta and ileofemoral arteries) while the human lesion is more frequent and more severe in the larger muscular arteries of the extremities. The plaques were found in the inner three-quarters of the aortic media (Fig. 1). The largest plaques were two-thirds of the circumference of the aorta and three-quarters of the thickness of the aortic wall. Most plaques were sufficiently calcified to obscure all cytological detail in hæmatoxylin- and eosin-stained sections; after decalcification with hydrochloric acid, elastic lamellæ and smooth muscle cell nuclei were distinguishable in some, but others showed only amorphous debris. In some sections near the plaques there were many bluish, apparently calcific granules both along the elastic lamellæ and diffusely distributed in smooth muscle cytoplasm; also a few barely visible, bluish-staining granules (calcium ?) were found in the proximal aorta of 2 hibernators and the 1 non-hibernator all free of plaques. In some aortæ there was swelling and vacuolization of some smooth muscle cell cytoplasm, not consistently associated with calcification.

The findings in the laboratory animals were checked against the 53 wild ground squirrels. These were studied and dissected, and at least 50 per cent were determined to be more than one year of age. None

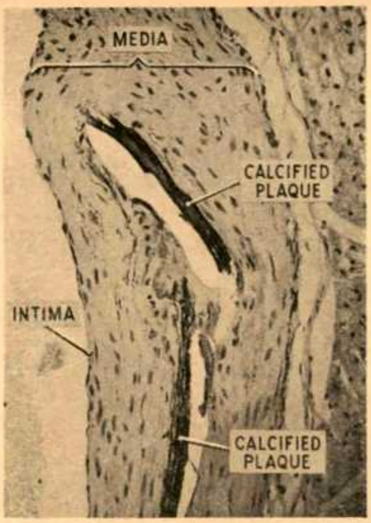

Fig. 1. Medial calcification in aorta of ground squirrel which did not hibernate during its life-span (three years). (× 110)

had aortic or ileofemoral arterial medial calcification. There was no atherosclerosis in any of the squirrels studied, wild or raised in the laboratory

Spontaneous aortic lesions like those in the ground squirrel have been described by Fox[5] in rabbits, cows, horses, wild canines, cats, marsupials and shore birds. It was not possible to determine from his account whether his material was more comparable to our laboratory series or to the field series. The lesions have also been produced experimentally by several methods, all relatively harsh[6]. Apparently diet did not produce the lesions in the present series since there was no evidence from a separate study of the teeth, weights and other indices, of any dietary abnormality in the laboratory squirrels. Spontaneous medial calcification increases with age in man[7,8], in the rabbit[9] and in the cow[5]. The same relationship would be expected in ground squirrels raised in an environment as nearly normal as laboratory conditions permit; yet none of the 3-year hibernating ground squirrels showed medial calcification (although found in 50 per cent of the controls). This evidence suggests that lowering metabolism (by hibernation) in some way reduces the occurrence of medial calcification in ground squirrels in the laboratory and probably also in the field environment of this local geographical area.

This investigation was supported by a grant from the National Science Foundation.

GEORGE R. ZIMMERMAN
G. EDGAR FOLK, JUN.
Departments of Pathology and Physiology,
State University of Iowa,
Iowa City.
Dec. 23.

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Reduced Activity of Histaminase in Rats sensitized by *Bordetella pertussis*

SINCE Parfentjev and Goodline[1] published their work on histamine hypersensitivity induced by inoculation of *Bordetella pertussis* (reviewed by Kind[2]) a number of papers on the subject have appeared; but little has been reported of the related biochemical changes in connexion with susceptibility to histamine. Inactivation of histamine by lung tissues from mice inoculated with *B. pertussis* was reported by Kind *et al.*[3] to decrease as compared with tissues from uninoculated mice. But this interesting result was not repeated by the same authors. More recently, Fishel[4] has examined changes in amino-acids, histamine and glutathione contents in various organs from inoculated mice, revealing no specific changes referable to histamine hypersensitivity. The present communication deals with the results concerning reduced activities of histaminase in tissue of rats inoculated with *B. pertussis*.

Bordetella pertussis, phase 1, No. 18-323, was cultivated in a synthetic medium originally described by Kuwajima *et al.*[5] at 37° C. for 96 hr. The grown cells were centrifuged and the supernatant was incubated in the presence of 1/5,000 merthiolate at 37° C. for 48 hr. to detoxify lethal toxin. Male albino rats (Wistar strain) weighing 100–200 gm. were sensitized by a single intraperitoneal injection of 3 ml. of the supernatant. Tissues from the inoculated and the uninoculated rat were taken on the fifth day and homogenized in a glass homogenizer with 5 vol. of cold phosphate buffer (*p*H 7·4, *M*/15). A supernate obtained by centrifugation of the homogenate was dialysed against the same buffer at 4° C. for 20 hr. and assayed for histaminase by the method of Kapeller-Adler[6]. The standard assay system contained 5·5 ml. of the supernatant, 4·0 ml. of phosphate buffer (*p*H 7·4, *M*/15), 3·0 ml. of $1{\cdot}43 \times 10^{-3} M$ indigo disulphonate (Merck), 20 μgm. of flavine adenine dinucleotide and 3·0 ml. of $5{\cdot}5 \times 10^{-3} M$ histamine dihydrochloride or water. One drop of chloroform was added as a preservative. 2½ ml. of an aliquot taken at each incubation period was assayed in duplicate for histaminase activity.

Table 1. HISTAMINASE ACTIVITY OF LUNGS OF RATS SENSITIZED WITH *B. pertussis*

Normal	Sensitized
622*	257*
789	330
697	330
856	293
767	—
Mean 746 ± 112	330 ± 55·7

Statistically significant ($F_s = 85{\cdot}3 > F'_7 (0{\cdot}01) = 12{\cdot}25$).

* Histaminase activity: expressed as μgm. histamine degraded per gm. tissue, in 24 hr., at 37° C.

As shown in Table 1, the histaminase activity of sensitized rats was significantly reduced as compared with normal rats. In six subsequent experiments with 3 animals per group, a decrease in histaminase activity was again produced and examined statistically (ratio for decrease between the inoculated and the uninoculated rats is 59·5 ± 10·5 per cent for lung, 38·0 ± 14·3 per cent for liver). With tissues other than the lung and the liver, no definite histaminase activity was detected because the activity of such tissues was too low and because of the relatively higher blank titres. The decrease in histaminase observed can scarcely be ascribed to a general depression of the metabolic activity, or to a shortage of prosthetic groups, because the inoculated animals were apparently healthy and enzymes other than histaminase, such as succino-oxidase or monoamine oxidase, showed no significant difference in their activities between the normal and the inoculated rat liver. The succino-oxidase activity was 274 and 296 µl. oxygen/100 mgm. tissue in 30 min. in the normal and the inoculated liver respectively. Monoamine oxidase was assayed with tyramine according to Creasy's method[7]. The uptake of oxygen was 237 and 220 µl./gm. tissue in 30 min. in the normal and the inoculated liver respectively. It is considered that reduced activities of histaminase may provide a clue to the explanation of histamine hypersensitivity in animals inoculated with *B. pertussis*.

MAKOTO NIWA
YUTAKA YAMADEYA
TOSHITAKA MATSUI
YOSHIO KUWAJIMA

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SINCE the work described above was carried out we have investigated the reduced inactivation of histamine by liver and brain from mice sensitized with *B. pertussis*. Histamine was added to a homogenate of the organs. Then the amount of histamine remaining after various intervals of incubation at 37° C. was determined by extracting histamine by a modified McIntire's method[1] and using guinea pig ileum. The extract responded to atropin and antihistamines in much the same way as histamine did. The liver and brain of sensitized mice showed a statistically significant reduction in the histamine-inactivating activity over non-sensitized mice.

The failure of reproduction of a reduced inactivation of histamine in mice sensitized with *B. pertussis*, as reported by Kind and Woods, may be due to their use of a more dilute homogenate than ours and a crude mixture instead of histamine extract.

TOSHITAKA MATSUI
MASAYOSHI KISHIGAMI
YOSHIO KUWAJIMA
Department of Bacteriology,
Osaka City University Medical School, Osaka.

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Secretion of Two Types of Saliva by an Aphid

NEARLY all phytophagous Hemiptera, including aphids, secrete a salivary material which coagulates rapidly on ejection to form a 'stylet-sheath' enclosing the path of the stylets in food materials and even in agar gel[1] and liquids[2]. It has been reported[3] that some Heteroptera secrete in addition a separate watery and water-soluble saliva which is emitted and sucked back both on the surface of substrates and within them. However, opinions differ on whether jassids secrete one type of saliva from which water-soluble substances diffuse before it gels[4] or two distinct types of saliva[5]; and among the Homoptera generally, only a sheath-forming secretion has hitherto been demonstrated conclusively.

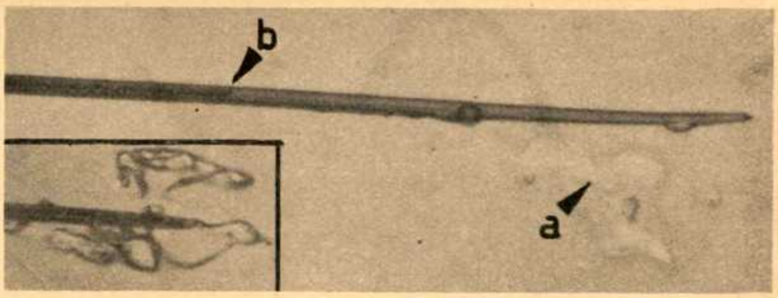

Fig. 1. Photomicrographs of the stylet bundle (with food canal uppermost) and salivary secretions of *Aphis craccivora*. (*a*) Sheath material secreted on to the underlying glass slide; (*b*) the meniscus of a watery secretion which has been discharged from the salivary canal and sucked back into the previously empty food canal. Inset, sheath material being extruded from the tip of the stylet bundle

The salivary secretions of aphids are of particular interest since they can act as vehicles for many plant viruses and may also inhibit them[6]. Due to the smallness of the insects it is difficult to determine whether, during feeding, they emit any non-coagulating saliva in addition to the sheath-material; but the following observations indicate that *Aphis craccivora* Koch does in fact produce two types of salivary secretion.

The insects were cemented by the dorsum to a pinhead, anæsthetized with carbon dioxide, and secured so that the stylets, which were first slipped out of the rostrum, lay flat on a clean, dry glass surface. It was observed under the microscope that as soon as the insect became active again, the contents of the food-canal were suddenly sucked back, leaving the canal totally or partially filled with air. The mandibles would then begin to slide backwards and forwards over the maxillæ, and almost invariably a highly viscous secretion was discharged in a manner suggesting the extrusion of artists' oil paint from a tube. This secretion solidified almost immediately it left the stylets and was evidently sheath material. Occasionally, it was also possible to see sudden flushes of watery liquid issuing from the tip of the stylets, but the most convincing evidence that another secretion was produced was the sudden sucking back of liquid up the empty food-canal. The rapid movement of this liquid and its appearance at times when no sheath material was being discharged precluded the possibility that it was the latter secretion. Further, since no liquid passed down the food-canal, regurgitation of gut contents could not have occurred. It is evident, therefore, that *Aphis craccivora*, similarly to Heteroptera, secretes a watery saliva distinct from the material which forms the stylet-sheath.

P. W. MILES
Waite Agricultural Research Institute,
University of Adelaide. Dec. 22.

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Bloat in Cattle

Much experimental work has been done on the causes of legume bloat in cattle and the prevention of its occurrence in the field (for reviews see Johns[1]). Several substances have been isolated from the feed or the animals' saliva, and have been reported to be responsible for the foam in the rumen of a bloated cow; but it has not been shown that any of these substances occur in the foam found in the rumen, and no attempt has been made to isolate the surface-active compound responsible for the foam directly from the rumen contents of a cow grazing clover or lucerne.

In my experiments, serial samples of rumen fluid were taken from cows through a permanent fistula, commencing before the beginning of either eating freshly cut clover and lucerne in the stall or grazing a new area and continuing for 6 hr. The pH, eH, total volatile fatty acid and ammonia nitrogen of the samples were determined. The remaining liquor was treated with 'Hyflo Supercel' to aggregate the suspended particles, and the straw-coloured filtrate was collected at the pump. The filtrate was found to foam considerably on shaking. The constituent responsible for the foam was not precipitable by mercuric chloride in the hot and was unaffected by a few minutes boiling with nitric acid or sodium hydroxide, but was decomposed by boiling for $\frac{1}{2}$ hr. with 3 per cent nitric acid. It did not pass through a dialysis membrane. The foaming constituent was precipitated from solution by the addition of ethanol to a concentration of 70 per cent at pH 4. After centrifuging off, the ethanol precipitate was redissolved in water to give a solution which foamed on shaking, indicating that the compound was not denatured by the alcohol precipitation. These results suggested that the constituent was carbohydrate in nature. The ethanol-precipitated material was hydrolysed for 4 hr. with 3 per cent nitric acid free from nitrogen peroxide containing a crystal of urea and the neutralized hydrolysate chromatographed on filter paper. The main constituents were the sugars normally found in the pectin and hemicellulose fractions of plants.

In each of the three experiments it was found, by using an accurate empirical laboratory method, that maximum foaminess occurs in the rumen 1–2 hr. after the cow began eating clover or lucerne, and fell away 4 hr. later to the pre-feeding level; the rumen contents of these cows were more foamy at all times than the contents from any cow eating grass or winter rations. This observation suggested that the foaming constituent appeared in solution in the rumen liquor after the plant had been physically broken down, and that it later disappeared, probably by the degrading action of the micro-organisms.

The whole picture of the fermentation, in the rumen of a cow eating clover or lucerne, is of a rapid reaction, as indicated by the high volatile fatty acid and ammonia nitrogen concentrations with copious gas production, the latter being entrapped in small bubbles in the rumen liquor owing to the presence of the pectins and/or hemicelluloses. It is important to note that under these feeding conditions, both the requirements for foaming to occur, namely, high gas production and the presence of a surface-active agent, are satisfied together and bloating may therefore occur. Each factor occurring on its own in this or any other situation may have no detrimental effect on the animal. The postulation that plant pectins and hemicelluloses are the substances responsible for the formation of a foam in the rumen of bloating cows does not preclude absolutely that other factors may be involved.

I wish to thank Dr. G. S. Pope for assistance with the chemical tests on some samples of rumen liquor.

M. J. Head

Chemistry Department,
National Institute for Research in Dairying,
Shinfield, Reading. Jan. 7.

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PLANT PHYSIOLOGY

Effects of Auxins on Membrane Permeability and Pectic Substances in Bean Endocarp

It has been shown[1,2] that auxins delay the onset of senescence in bean endocarp and various leaf tissues (*Rhoeo*, *Mesembryanthemum*) maintained *in vitro*. In the absence of auxin, liquid-logging of intercellular spaces is followed by cellular dissociation and rounding off of cells. Similar changes have been observed in the abscission zones of *Coleus*, *Cestrum* and *Fuchsia*. When de-seeded bean pod segments are maintained in Petri dishes on wet filter paper, liquid-logging is evident in 2½–3 days and an exudate appears on the upper tissue surfaces. Cellular dissociation is usually complete by the fifth day. These changes are essentially prevented by the addition of an auxin (3-indoleacetic acid or α-naphthaleneacetic acid) to the culture medium. There are no significant differences in increase in fresh weight or respiratory activity between water- and auxin-treated endocarp segments over a ten-day period. The cells of liquid-logged segments are still capable of plasmolysis and deplasmolysis. The results indicate that the liquid-logging and exudation are manifestations of changes in permeability. A second process involves changes in the composition of the cell-wall cementing substances which take place in the absence of auxin and give rise to cellular dissociation and rounding off of cells.

Previous studies[3-6] have implicated pectin methylesterase as one of the enzymes directly affected by auxins. For pectin methylesterase, auxin appears to act through an adsorption–desorption mechanism which controls the activity of the enzyme in the tissue.

The results presented herein concern the nature of the permeability changes and the role of pectic enzymes in the processes causing cellular dissociation. Bean segments were prepared as before[2], and the exudate from water-treated segments collected for analysis. On addition of 3 vol. of ethanol, a precipitate was formed which was collected by centrifugation. The precipitate was dissolved in alkali, reprecipitated by acidification, and digested with a commercial pectinase preparation. The only substance detected in the digest was galacturonic acid. Analysis of ethanol-soluble substances in the exudate showed the presence of amino-acids, traces of organic acids and a large amount of a non-reducing sugar, which was identified as sucrose by paper chromatographic methods as well as identification of the hydrolytic products. Quantitative determination of the sucrose in the earliest-obtainable exudate gave a figure of $0 \cdot 029\ M$. The osmotic pressure of the same exudate was found to be $0 \cdot 050\ M$, thereby showing that sucrose is the major osmotic constituent. Ash analyses indicated that inorganic ions contribute much of the osmotic pressure not accounted for by sucrose. Since the exudate is continuous with the liquid in the free space of the tissue, there are large amounts of solutes, including soluble pectic substances, in the walls of exuding segments. The presence of sucrose in the exudate indicates an increase in permeability as sucrose is not a hydrolytic product of wall polysaccharides.

The nature of the permeability changes was further investigated by measuring the apparent osmotic volume of the tissue with respect to sucrose, and relating these changes to the liquid-logging and exudation occurring in segments maintained in the absence of auxin. The apparent osmotic volume was measured by the method of Briggs *et al.*[7]. In this measurement permeability changes are indicated by a large decrease in the apparent osmotic volume of the tissue with respect to the solute used for the determination. The results for two different batches of beans show that the time at which the osmotic volume of water-treated segments commences to fall rapidly is correlated with the onset of liquid-logging and exudation, and that all these changes are markedly reduced or prevented by the addition of auxin to the medium.

The similarity of the microscopically observable sequence of events which occur in abscission zones of certain plants and in bean endocarp segments, coupled with the fact that auxin alters these events in a similar way, presented the opportunity to test a hypothesis[8] which purports to explain the auxin-controlled changes occurring in the cell-wall cementing substances of abscission zones. This hypothesis invoked the combined action of pectin methylesterase and endopolygalacturonase. The latter enzyme has been shown to act much more rapidly on de-esterified pectins, and an increased reaction-rate is therefore a natural consequence of the presence of an active esterase. It was proposed that the solubilization of pectic substances in abscission zones could be brought about by desorption (activation) of pectin methylesterase at low levels of auxin. If the hypothesis is correct and the auxin-controlled processes of abscission zones and bean endocarp are indeed analogous, it follows that pectin methylesterase should be present in the exudate from water-treated endocarp segments. Assays were carried out using a manometric technique described previously[5] and the presence of the enzyme in the exudate established. The actual amount of enzyme increased in an approximately linear manner over the 4-day period.

In further support of the above hypothesis explaining solubilization of pectic substances, evidence has been obtained for the presence of a polygalacturonase-like enzyme capable of reducing the molecular size of pectic acid. The occurrence of this enzyme has been reported only in a few instances in higher plants (tomato[9], avocado[10], pear[11]). Viscosity measurements were carried out on pectic acid solutions using either tissue slices or a cell-free extract as the enzyme source and with appropriate controls. Significant reductions in viscosity were measured in both cases.

These results show that a low level of auxin in bean endocarp gives rise to permeability changes and to alterations in pectin metabolism which are correlated with liquid-logging, surface exudation and cellular dissociation. The results suggest that the action of auxin may be a surface phenomenon affecting the physico-chemical characteristics of cellular membranes and interfaces as previously proposed by Veldstra and Booij[12]. Two of the manifestations of this effect would be changes in membrane permeability and changes in the amount of pectin methylesterase adsorbed at cellular interfaces. Full details of this work will be published elsewhere.

This work was supported by the National Science Foundation (U.S.) and the Colonial Sugar Refining Co., Ltd., Sydney, Australia.

J. A. SACHER*
K. T. GLASZIOU

Division of Biology,
California Institute of Technology,
Pasadena, California.

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* Permanent address: Los Angeles State College, Los Angeles 32, California.

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Carbohydrate Constituents of the Mycelium of *Penicillium chrysogenum* grown in Media with Different Sources of Carbon

THERE are several reports on the carbohydrate constituents of the mycelium of different strains of *Penicillium chrysogenum* grown under different conditions. The presence of mannitol, erythritol, a polysaccharide containing glucose, mannose and galactose[1], pentosan[2], phosphates of mannose, and inositol[3] and of glucose, fructose, pentose and heptose[4] have been reported. Shu and Thorn[5] grew *P. chrysogenum* *Q*176 in Czapek–Dox medium with 5 per cent glucose, galactose and xylose individually as the sole carbon source and reported that the mycelial hydrolysate in each case consisted of glucose.

We have grown *P. chrysogenum* (strains *HA*-6 and *HA*-9, used in production here) in shake flasks in the synthetic medium of Gitterman and Knight[6] with 2 per cent sucrose, lactose, glucose, galactose, fructose, L-sorbose, mannitol, *myo*-inositol, *myo*-inosose-2, glucuronolactone, ribose, xylose, L-arabinose, glycerol and sodium acetate as the sole carbon sources. The inoculum was the centrifuged and re-suspended 'seed mycelium' (used for inoculating the big fermentors) grown in the 'seed tanks' of the plant in corn-steep–sucrose medium with aeration and agitation for 48 hr. after inoculation with spores. When the carbohydrate in the medium was almost exhausted (3–8 days), the cells were collected, washed with water and dried. In addition, three samples of 'seed mycelia' (S_1, S_2, S_3) and three samples collected from the fermentors (*F*-1374, *F*-2380 and *F*-2382) at the end of fermentation (98–110 hr.) were also taken up for comparative study.

The dry, well-powdered mycelium (100 mgm.) was extracted three times with ether, three times with *iso*propyl alcohol (which removed mannitol), and then three times with cold water to give a total of 10 ml. of the cold-water extract (*A*). The residual mycelium was treated with 1 ml. of 80 per cent

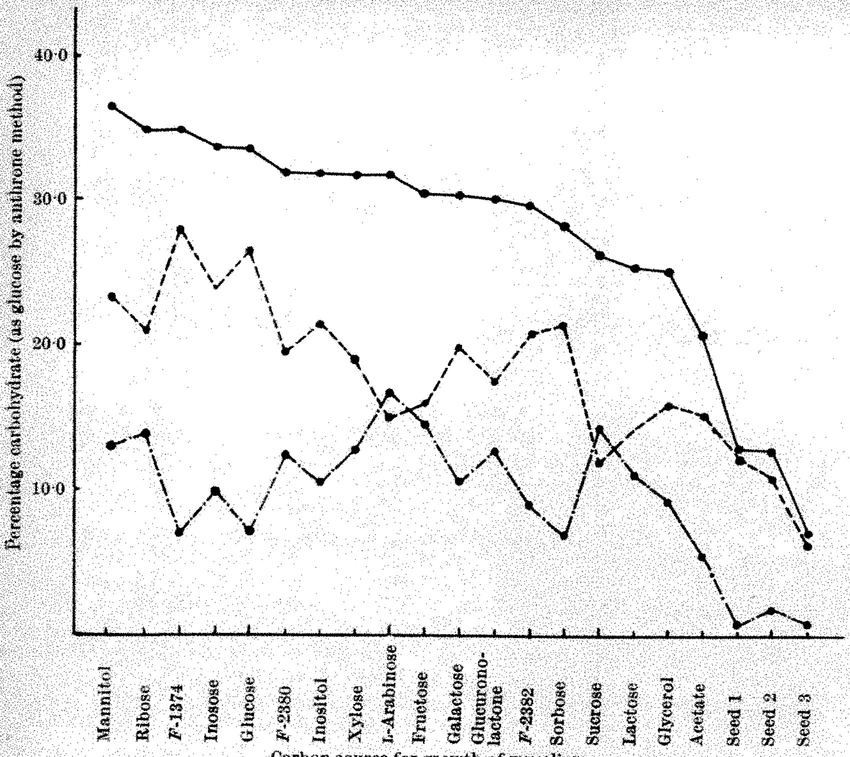

Fig. 1. The carbohydrate content of the aqueous extract (*A*), the polysaccharide (*B*), and total carbohydrate (*A* + *B*) as estimated by anthrone method and expressed in terms of glucose. The samples are arranged in the descending order of total carbohydrate content. —·—·, *A* ; – – – –, *B* ; ———, *A* + *B*

sulphuric acid, allowed to stand for about 2 hr. for solution and then diluted to 10 ml. The insoluble material (probably chitin) which separated was filtered off, and the filtrate (*B*) heated on a boiling water-bath for 3 hr. to give the hydrolysate (*C*). The carbohydrate content of (*A*) was assayed by the anthrone[7], Somogyi[8] and periodate[9] methods (to detect the relative amounts of polysaccharides, reducing sugars and sugar alcohols), of (*B*) by the anthrone method (to estimate the polysaccharides) and of (*C*) by the Somogyi method. The results obtained are presented graphically in Fig. 1.

The aqueous extracts and neutralized hydrolysates were passed through 'Dowex 50' (H⁺) and analysed for sugars by the spectra with unsulphonated and presulphonated resorcinol according to the method of Devor, Conger and Gill[10] and by descending paper chromatography on Whatman No. 1 paper, using 80 per cent *iso*propyl alcohol as the solvent and silver nitrate, aniline phthalate and phloroglucinol as dip reagents. For confirmation, water eluates of the paper strips cut out from the chromatogram corresponding to the various spots were analysed by the resorcinol spectra[10]. The results obtained and the points of interest that emerge from these studies are as follows :

(1) *Total carbohydrates* (*A* + *B*). This varies from 20·6 to 36·5 per cent, depending upon the nature of the sugar used, with no correlation being apparent between this percentage and the structure of the sugars.

(2) *Water extract* (*A*). This accounts for 20–52 per cent of the total carbohydrates in the various samples. The component sugars seem to be almost the same in all the samples, though there are quantitative differences. Glucose accounted for about 90 per cent of the total, probably with traces of galactose. Chromatography revealed five more carbohydrates—ribose, three disaccharides giving glucose on hydrolysis, one of which is most probably trehalose, and one with R_G 140 which does not appear to be glucuronolactone.

(3) *Hydrolysates* (*C*). All the samples were found to consist of the same sugars. Glucose was again the predominant sugar with perhaps traces of galactose. In addition, there were a sugar with R_G 50 which is not inositol, the compound with R_G 140, and a compound with R_G 110 which is not fructose or sedoheptulose and gives a complex resorcinol spectrum. Ribose was not detected. There is an inverse correlation between the percentage of the sugar content in the aqueous extract (*A*) and the hydrolysate (*C*), the significance of which is not clear at the moment.

(4) *Seed Mycelia*. These stand out as a class by themselves. The total carbohydrate content and also the percentage of the sugar in the aqueous extracts are low. The aqueous extract consisted of fructose, ribose, a small quantity of glucose, traces of trehalose and the sugar with R_G 140. On hydrolysis of this aqueous extract with *N* sulphuric acid for 30 min., the sugar content apparently increased two- to three-fold, and galactose appeared as the predominant sugar in the hydrolysate. The hydrolysate of the water-extracted residual mycelium was found to be of the same pattern as the hydrolysates (*C*) of the other mycelia, except that ribose was also detected here.

P. chrysogenum can utilize a variety of sugars and carbon sources for growth, though the degree of growth varies. It is striking that, irrespective of the nature of the sugar or the carbon source used in the medium, the component sugars in the aqueous extract (*A*) and the hydrolysate (*C*) remain the same, glucose being most predominant. There exists, therefore, a mechanism for the conversion of all the sugars and carbon sources first into glucose, which afterwards becomes converted into the polysaccharide. To elucidate these metabolic pathways, we are analysing the culture fluids for intermediates in the growth experiments with the various sugars. The concentration of sugars in the 'free sugar pool' of the aqueous extract would be the resultant of the quantity of the sugars synthesized from the media component and the drain by the conversion into the polysaccharides. It could be expected that, when the rate of growth of the mycelium is low with little demand from the 'free sugar pool', there would be an accumulation of these sugars in the pool and vice versa. The latter situation seems to be prevailing in the fast multiplying seed mycelia. The difference we have noticed between the 'seed mycelia' and the full-grown one in the fermentors probably explains why the former produces no penicillin at all while the latter does[11]. The presence of free glucose and ribose and also the large percentage of sugars in the 'free sugar pool' of the aqueous extracts is of interest. Whether the sugars exist as such or are produced during the processes of extraction is being studied. The free ribose detected need not be a degradation product of nucleic acids, but could be the excess produced over what is diverted for the synthesis of the nucleotides and also used up for conversion into glucose.

Full details will be published elsewhere.

Roshan J. Irani
K. Ganapathi

Antibiotics Research Centre,
Hindustan Antibiotics, P., Ltd.,
Pimpri (Poona District),
India. Dec. 15.

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Control of Superficial Scald in Stored Apples

Although superficial scald of apples is effectively controlled by wrapping in paper impregnated with mineral oil the labour involved in doing so renders the method expensive, and the search for alternative methods of control continues. Fidler[1] has shown that the view that superficial scald is attributable to an injury to the tissues caused by volatile products of the metabolism of the fruit fails to explain many of the observed phenomena. He has suggested that an interaction between a heavy volatile substance *Y* which cannot be removed from proximity to the fruit by ventilation and a non-volatile substance *X* produces a compound or compounds toxic to the skin. Recent observations made during the course of experiments on the control of low-temperature injury would seem to support Fidler's view.

Apples of the variety Bramley's Seedling were picked from twelve large trees at three different dates. Comparable samples were made up within each harvest and were stored on trays in air at 0° C. Four trays from each harvest were placed at 15·5° C. for 5 days commencing with the date of picking and afterwards at intervals until the thirtieth week. Up to the twelfth week the warming was applied at fortnightly intervals. No tray of fruit was subjected to warming more than once.

Fig. 1 shows the percentage of fruits affected in the second harvest after 34 weeks from the date of storing. The relationship shown is characteristic also of that obtained with the two other harvests, although the amount of scald in the last pick was small, as is usual with fruit of more advanced maturity. There was a progressive reduction in the percentage of apples with superficial scald and a diminution of severity with warming at successive intervals of time from the second to the twelfth week and a complete absence of scald when the apples were warmed at the sixteenth and twentieth weeks. Scald was very marked on the fruit treated at the thirtieth week. It has hitherto been considered that the damage to the fruit, although it does not become manifest until later, is incurred before the sixth–eighth week after putting into store[2]. These results suggest that this is not necessarily so.

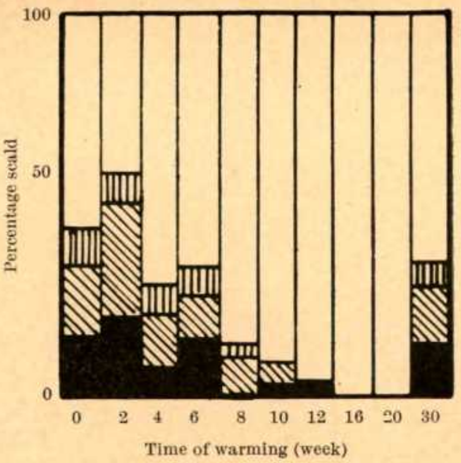

Fig. 1. Effect on the occurrence of superficial scald of keeping Bramley's Seedling apples for 5 days at 15·5° C. at successive stages during storage at 0° C. Vertical hatching, slight scald; oblique hatching, moderate scald; black, severe scald

Kidd and West[3] observed that very brief intermittent warming of Newton Wonder apples during storage at 3° C. reduced the amount of scald. Treatment, however, commenced early in the storage life and was continued throughout the period.

A possible explanation of the result described above is that the combination of substances *X* and *Y* is cumulative and reversible at higher temperatures, so that when warming is carried out prior either to the build-up of a sufficient concentration of the toxic substance or before the substance has had time to react lethally upon the cells, no scald injury results. If, however, the time-interval exceeds a certain limit, scald will appear in an amount increasing with extension beyond this limit. Although in Fig. 1 no observations are recorded for warming at intervals between the twentieth and thirtieth week, it can safely be assumed that, had they been made, an upward gradation in the amount of scald would have appeared in this interval.

From the practical point of view change of temperature would seem to be a possible method for control of superficial scald provided the fruit could be stored at 0° C. without low-temperature injury or provided the same effect could be secured at a temperature of storage above the critical level for low-temperature injury.

W. Hugh Smith

Department of Scientific and Industrial Research,
Ditton Laboratory,
Larkfield, Maidstone, Kent.
Dec. 30.

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BIOLOGY

The Possibility of distinguishing between Substances shown on Electron Micrographs

THE electron microscope can be used to investigate the morphological features of a specimen right down to the molecular level, but there is as yet no way of identifying the chemical nature of the substances seen, except on the rare occasions when these happen to be crystalline. In a specimen of uniform thickness, a region of high electron opacity may, in general, be said to be one containing substances of a greater weight density than those of the surrounding less opaque region[1], but this gives little help in deciding on their chemical composition. The lack of any direct way of knowing what substances one is looking at is perhaps the most serious shortcoming of electron microscopy.

It thus seems worth describing a simple way in which the image formed by an element of high atomic number differs from that of an element of low atomic number. Biological substances seldom vary significantly in the mean atomic number (calculated on a weight basis) of the elements composing them, but the method to be described can be used, for example, to identify which parts of a specimen have taken up an added 'stain' of high atomic number.

It is well known that the contrast between the different features of a biological specimen can be increased by reducing the size of the objective-lens aperture. This observation is in good accord with the theory of electron scattering deduced from considerations of quantum mechanics[2,3]. Hall and Inoue[4], for example, found that when the angular aperture of the objective was reduced from $4 \cdot 2 \times 10^{-3}$ to $2 \cdot 1 \times 10^{-3}$ radian, the scattering cross-section of polystyrene latex increased by 30 per cent. Lenz's theory[2,3] predicts an increase of about 25 per cent. But with an element of high atomic number, theory suggests that the size of the aperture will have little effect on contrast. I have made observations which in fact confirm this; for, unlike carbon, films of gold, platinum and tungsten show no detectable change in opacity when the objective aperture is changed for one of half the size.

The method of differentiating substances of high atomic number from biological or other material of low atomic number thus consists simply of taking two electron micrographs of the same field using a different-sized aperture for each. With many microscopes, changing the aperture involves only a simple manipulation that does not even require the beam to be switched off. The two plates are similarly exposed and developed. All substances with a mean atomic number (Z) less than 12 should show an image of markedly different density on the two plates. Two conditions, however, must be satisfied for this change to be seen. First, the image of any object under test must be considerably less dense than the background of supporting film (that is, the object must have a sufficient electron opacity): secondly, the plates must be exposed for long enough to give this image an optical density of about $0 \cdot 5$ or more (that is, distinctly darker than an unexposed part of the plate). If these conditions have been satisfied, then an object showing no change in opacity may be safely identified as one containing a large content of material with an atomic number greater than 20.

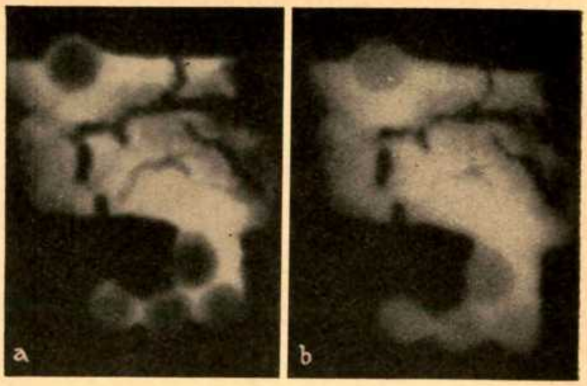

Fig. 1. Electron micrographs of polystyrene latex spheres surrounded by phosphotungstic acid (× 45,000); (*a*) using an objective aperture of 10^{-2} radian; (*b*) using an objective aperture of 5×10^{-3} radian

As an example of the method, Fig. 1*a* shows an electron micrograph of some polystyrene latex spheres surrounded by a dried-down mass of phosphotungstic acid. The latex spheres were less opaque than the phosphotungstic acid and can be clearly distinguished. A second plate was exposed of this same field but using an objective aperture of half the size. The plate was reproduced in exactly the same way and is shown in Fig. 1*b*. (Both figures are printed as negatives, that is, as the original plates.) The latex particles are now almost indistinguishable from the surrounding material, the polystyrene latex (mean $Z = 5 \cdot 6$) having gained considerably in opacity while the phosphotungstic acid (mean $Z = 58$) did not. The demonstration is made more vivid if the plate shown in Fig. 1*a* is projected in red light and the image superimposed on that of Fig. 1*b* projected in green light. The objects of low atomic number then appear green against the material of high atomic number, which looks yellow.

A full mathematical treatment of this topic will be given elsewhere, but it seems that a quantitative application of the method would allow one to differentiate calcium ($Z = 20$) or even phosphorus ($Z = 15$) from, say, protein (mean $Z = 7$). It would not, however, be possible to distinguish between the chief biological materials, proteins, carbohydrates, lipids and nucleic acids in this way, or to distinguish between any of the higher elements ($Z > 25$).

ROBIN C. VALENTINE
National Institute for Medical Research,
Mill Hill,
London, N.W.7.
Jan. 30.

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Enzymic Hydrolysis of Fucoidin by *Pseudomonas atlantica* and *Pseudomonas carrageenovora*

FUCOIDIN, a common polysaccharide sulphate in brown seaweeds, has been shown by methylation[1,2] and acetolysis[3] to consist of a chain of L-fucopyranose units joined in α-glycosidic linkages through carbon atoms 1 and 2 of adjacent units, each unit being sulphated on carbon atom 4. The results obtained from methylation studies also indicate that 1 : 3 and 1 : 4 linkages are present. A fucoidinase would greatly assist further studies on the structure of fucoidin. The object of this communication is to report the discovery of such an enzyme obtainable from two species of marine bacteria.

Fucoidin was prepared from *Fucus vesiculosus* by extraction with hot water[4]. Bacterial cultures were taken from a private collection of marine bacteria which had been used for degradative studies of agar and carrageenin. They had been isolated from seawater and marine algae in the neighbourhood of Halifax, Nova Scotia. *Pseudomonas atlantica*[5] hydrolysed agar and a Gram-negative rod hydrolysed carrageenin[6]. The latter was afterwards shown to have a polar flagellum and is now named *Pseudomonas carrageenovora* n.sp.

The micro-organisms were grown for 72 hr. at 20° C. on a rotary shaker in a medium which contained sodium chloride, 30·0 gm.; dipotassium hydrogen phosphate, 1·0 gm.; crystalline magnesium sulphate, 0·5 gm.; sodium nitrate, 0·5 gm.; ferric chloride (1 ml. of a 2·0 per cent solution); fucoidin, 2·5 gm./l. of distilled water.

The utilization of fucoidin by the marine bacteria was determined from the fucose equivalents of aliquots removed from the control and fermentation flasks. The fucose equivalent of fucoidin was obtained by hydrolysing an aliquot of the medium with 0·5 *N* hydrochloric acid in a sealed tube for 18 hr. in a steam-bath. The hydrolysate was cooled, neutralized and the concentration of fucose determined by the method of Somogyi[7] with fucose as standard. The amount of fucoidin utilized by *P. atlantica* was 31·5 per cent and by *P. carrageenovora* 29·9 per cent.

The cell-free medium was used as the enzyme solution. One volume of enzyme solution was added to two volumes of 0·9 per cent solution of fucoidin in 0·2 molar phosphate buffer. Aliquots were removed at intervals, and the increase in reducing power, expressed as fucose, was determined by Somogyi's method[7].

The relationship between *p*H and enzyme activity is shown in Fig. 1. The enzyme activity was greatest around *p*H 7·0. After 24 hr. at 40° C. and *p*H 7·0 the apparent degree of conversion of fucoidin to fucose by enzmye preparations from *P. atlantica* and *P. carrageenovora*, was respectively 24·2 per cent and 15·9 per cent (Table 1).

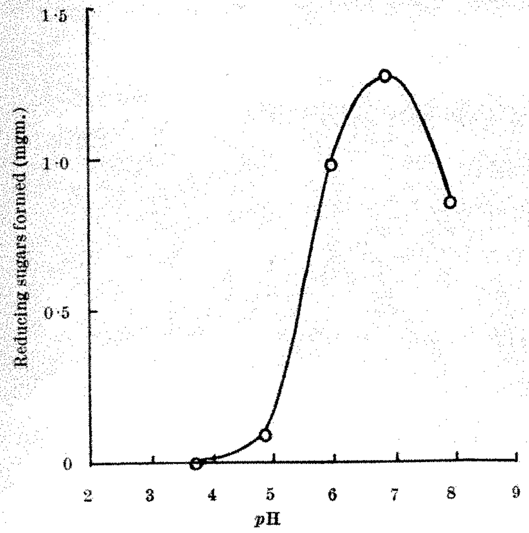

Fig. 1. The relationship between *p*H and enzyme activity. Reducing sugar as fucose after 3 hr. at 40° C. Enzyme solution from *Pseudomonas atlantica*

Table 1. ENZYMIC HYDROLYSIS OF FUCOIDIN

Enzyme from	Fucose (mgm.)		Hydrolysis of fucoidin (per cent)	
	3 hr.	24 hr.	3 hr.	24 hr.
P. atlantica	1·07	2·10	12·3	24·2
P. carrageenovora	1 19	1·39	13·7	15·9
*P. atlantica**	—	0·81	—	8·9

* Enzyme solution heated for 10 min. at 100° C.

The enzyme solution was heated for 10 min. at 100° C. and then added to the fucoidin. Results in Table 1 show an 8·1 per cent hydrolysis of fucoidin in the cell-free mixture. A similar effect was noted in previous experiments with a *K*-carrageenase. Further studies are planned on the purification of the enzyme and identification of the hydrolytic products.

W. YAPHE
K. MORGAN*

Atlantic Regional Laboratory,
National Research Council,
Halifax, Nova Scotia.
Dec. 29.

* Post-doctorate Fellow of the National Research Council of Canada.

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Marlins in British East African Waters

THE first confirmed report of the striped marlin (*Makaira audax*) in the Indian Ocean was that of Smith[1], who recorded details of a 160-lb. specimen of 89 in. (2,260 mm.) standard length from Mossel Bay, South Africa. Morrow[2] reported having seen the striped marlin off Pemba Island and Mombasa in 1950; but no specimens were caught or examined. Copley[3] records a so-called striped marlin taken by him off Mombasa in 1934 (weight, 127 lb.) but does not mention the striped marlin at all in his "Game Fishes of Africa"[4].

I agree with Smith[1,5] that the name *M. audax* Phillipi 1887 for the striped marlin has priority over *M. mitsukurii* (Jordan and Synder) 1901 used by LaMonte[6] and most American workers prior to that publication. LaMonte hoped that a change in the law of priority under "The Rules" would allow *M. mitsukurii* to stand, but this was not so. *M. audax* has been used by later American workers, such as Royce[7] in his paper on the Central Pacific spearfishes, although Morrow[8] still retains the name *M. mitsukurii* in discussing races of the striped marlin in the Pacific.

During recent cruises of the *Manihine* (the research vessel of the East African Marine Fisheries Research Organization) during October–December 1958, a deep long-line was used for the capture of yellow-fin tuna (*N. macropterus*) and among the catch were 15 striped marlin—a further seven were lost while hauling. Catches were made between Malindi, Kenya (3° 20′ S.), and Mafia Island, Tanganyika Territory

Table 1. LENGTH AND WEIGHT OF *M. audax* IN EAST AFRICAN WATERS

	1954	1958														
Total length (mm.)	2,590	2,200	2,530	2,485	2,515	2,580	2,480	2,700	2,590	2,770	2,560	2,650	2,800	2,735	2,760	2,830
Standard length (mm.)	2,250	1,860	2,150	2,185	2,160	2,210	2,125	2,300	2,250	2,325	2,180	2,360	2,510	2,360	2,450	2,395
Weight (lb.)	115	75	105	115	120	127	130	130	135	145	148	150	160	165	185	190

(8° S.), 10–20 miles offshore. It would seem, therefore, that striped marlin are not so rare in these waters, at least during the last three months of the year, as records, or the lack of them, would suggest. A marlin taken by trolling on October 5, 1954 (at 7° 35′ S., 39° 54′ E.), and recorded in the annual report of this Organization for 1955–56 [9], as *Tetapterus brevistoris* Playfair was, from the details, undoubtedly a striped marlin. In Table 1, total and standard length in mm. and weight in lb. are given for East African specimens of *M. audax* taken so far.

Certain proportions for the East African specimens are compared with those for LaMonte's Pacific specimens and that of Smith from South Africa in Table 2.

Table 2. COMPARISON OF *M. audax* FROM THE PACIFIC OCEAN AND SOUTH AND EAST AFRICAN WATERS

	LaMonte Pacific specimens. Range	Smith South African specimen	East African specimens. Range
Head in standard length	2·46–2·72	2·61	2·64–3·02
Depth in standard length	5·4–6·58	6·59	5·70–7·03
Depth in pectoral length	1·0–1·8	1·53	1·16–1·43
Height of dorsal lobe in depth	= or less than 1	0·75	0·78–0·97
Height of dorsal lobe in pectoral length	1–1·3	1·15	1·04–1·34

East African striped marlin are brilliantly coloured —cobalt blue above and white below on the belly; the number of pale lavender coloured stripes varies considerably. On death, the fish becomes a uniform slate-grey above and pale below; the pale stripes persist after death for some time, but after refrigeration for a few days the stripes may be lost altogether.

It is interesting to note that no other species of marlin has been taken by this Organization (1951–to date) or seen by us in the fish markets of East Africa. It seems probable, however, that the black marlin is also present in these waters, although the records are somewhat dubious. Morrow[2] records a black marlin (*M. nigricans marlina*) from Pemba of 259 lb. and 2,151 mm. standard length, although Smith[5] points out that this is approximately 100 lb. greater than the average weight at that length. Similarly, Copley[10] records a so-called black marlin taken off the Kenya coast of 360 lb. at 3,365 mm. standard length, considerably less than the average for a black marlin of that size. *Histiophorus brevistoris* Playfair, said by Smith[5] to be the black marlin, is, I think, to be more correctly treated as *species indeterminata*, as did LaMonte[6], although Playfair's fish does possess more features like the black marlin than the striped. Playfair's type from Zanzibar was destroyed; the only species of marlin seen in Zanzibar markets in the past eight years has been *M. audax*.

Further details on the biology of the striped marlin will be given at a later date when the whole problem of long-lining off the East African coast will be discussed.

I must point out that *Marlina jauffreti* Smith 1956 [5], from Mauritius, was named purely on the details of a marlin visible in a not very clear photograph and a few notes received by Smith. Although a new species of marlin may be present in Mauritius waters, the establishing of a new species of fish on the basis of a photograph and without access to the fish itself at a later date (it appears to have been destroyed) is likely to introduce confusion to the system of nomenclature and is to be deprecated, especially in such a closely related group as the marlins.

F. WILLIAMS

East African Marine Fisheries
Research Organization,
Zanzibar. Jan. 3.

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Development of Ovarial Teratomas in Viviparous Toothcarps by Pathological Parthenogenesis

RECENTLY, I described three cases of pathological parthenogenesis in viviparous toothcarps, in which the stimulus required for the development of the unfertilized oocytes consisted in a local infection with the *Ichthyophonus* parasite, the phycomycete *Ichthyophonus hoferi* Plehn-Mulsow[1].

As some years ago I had observed in a *Lebistes* female an ovarial teratoma which also showed a close relation with an *Ichthyophonus* process[2,3], I was under the impression that teratomas can develop parthenogenetically in the viviparous toothcarps as well. I therefore decided to continue the systematic examination of the virgin females, hoping in this way to make some contribution toward explaining the origin of teratomas in general.

In this investigation one ovarial teratoma was observed on 1,484 adult virgin females of *Lebistes reticulatus* as well as on 1,179 adult virgin females of *Xiphophorus maculatus*, whereas on 946 adult virgin females of *Xiphophorus helleri* no ovarial teratoma was present.

The *Lebistes* teratoma, which was present in a 41-mm. female, was composed of connective tissue, musculature, cartilage, bone, blood vessels and nervous tissue, whereas in the *Xiphophorus* teratoma, occurring in a 68-mm. female, also intestinal structures, glandular structures and cysts could be demonstrated.

In both cases an *Ichthyophonus* process was present in the ovaries and in their surroundings, of which the cysts varied in size and were localized in the cranial part as well as in the caudal part of the organ.

For microscopic confirmation of the virginity of the fishes, the sperm chambers of the ovaries were examined; no spermia were found. On the strength of this finding, self-fertilization—a phenomenon accidentally occurring in the viviparous toothcarps and explained by the presence of a bisexual gonad producing spermia and oocytes—could be excluded.

The coincidence of the ovarian teratoma on one hand, and the occurrence of the *Ichthyophonus* infection on the other, justifies the assumption that the development of a tumour is caused by the *Ichthyophonus* toxin, which provided the artificial stimulus for the parthenogenetic development of an unfertilized oocyte to teratoma. In this case the pathological process resulted in the parthenogenetic development.

It is not known why, in the cases formerly described, the local *Ichthyophonus* process caused a parthenogenetical development of the unfertilized oocytes and in other cases a pathological development to teratoma. In the latter cases, the damage to the unfertilized oocytes by the agent causing inflammation may have been such that normal embryological development was no longer possible.

It may be remarked that Spurway[4] did not mention the occurrence of teratomas in the virgin *Lebistes* females.

A. STOLK

Histological Laboratory,
Free University,
Amsterdam.
Oct. 29.

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Ultrastructure of Pineal Eye Sensory Cells

WORK on the ultrastructure of photoreceptor elements in the lateral eyes of vertebrates[1-3] has advanced to the extent of becoming incorporated in a recent edition of a well-known text-book[4]. Ultrastructural research is also being done on invertebrate compound eyes[5,6]. So far as could be ascertained no work has yet been published on the ultrastructure of the eye-like pineal structures occurring in several vertebrate classes. For various reasons, such as compactness of pineal epithelia[7], small size of the structures involved[8] and bad preservation arising from fixation difficulties[9], there is considerable divergence of opinion and uncertainty regarding the nature and structure of the pineal sensory cells and their appendages as seen with the light microscope.

I have examined the ultrastructure of the inner and outer segments of the sensory cells in the adult pineal eye of the lizard *Cordylus polyzonus*. The structure of the appendages in this species has already been studied with the light microscope[10].

The material for the present study was fixed for 2 hr. in 1 per cent osmic acid buffered to *p*H 7·5 (veronal acetate) at 2° C. The fixation procedure previously employed[10] which involved injection of fixatives into, and their drainage from, the subdural cavity was abandoned in favour of, after paraldehyde anæsthesia, simply cutting out a flap of cranial roof containing the pineal eye and immersing this material in the fixative. This method, ensuring prope penetration, gave superior structural preservation The material was embedded in *n*-butyl methacrylate sectioned with a Porter–Blum ultramicrotome an studied under a Siemens electron microscope.

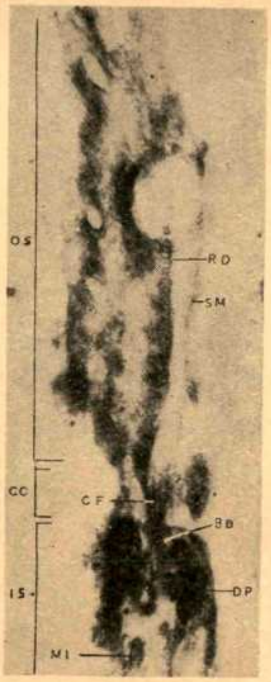

Fig. 1. Electron micrograph showing parts of the inner and outer segments of a sensory cell from the pineal eye of *Cordylus polyzonus*. The microstructure of these segments appears to be completely identical with that of the corresponding elements in the lateral eye. *BB*, basal body; *CC*, connecting cilium; *CF*, ciliary fibril; *DP*, dense particles; *IS*, inner segment of sensory cell; *MI*, mitochondria; *OS*, outer segment of sensory cell; *RD*, rod disks; *SM*, surface membrane. (× 16,000)

The results obtained indicate that, among possibl more than one type of sensory cell in the pineal eye there are sensory cells with inner and outer segment almost completely comparable in structure to th same elements in the vertebrate lateral eye. Thu the inner segment (projecting into the pineal ey lumen) contains mitochondria, dense particles and basal body in which a connecting cilium terminates This latter connects the inner segment to the oute segment, and is composed of a so far unknown number of ciliary fibrils, no cross-sections through th connecting cilium being available yet. Some of thes ciliary fibrils show up clearly, however, in Fig. 1 illustrating a longitudinal section through part of sensory cell. In the outer segment the surfac membrane and so-called rod disks are clearly recognizable, and appear to be identical with their counterparts in the rods of the vertebrate lateral eye. I view of the great similarity in the structure of th photoreceptory cells wherever they occur in th animal kingdom (that is, in lateral eyes of vertebrates in the compound eyes of insects and arachnids), th conclusion would seem to be justified that the cell of the pineal eye possessing a microstructure of th same type are actually photoreceptory cells. Furthe investigations on this subject are in progress.

I should like to record my appreciation of th interest shown in this work by Prof. B. I. Balinsky who gave me facilities for this work, and to than Miss A. de Kock and Mr. J. W. Matthews for skille technical assistance. I wish also to thank Dr. A. Brink and Mr. J. W. Kitching for their aid in connexion with material.

The work is supported by a grant from the South African Council for Scientific and Industrial Research.

W. STEYN

Department of Zoology,
University of the Witwatersrand,
Johannesburg, South Africa.
Dec. 22.

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Delayed Denervation and Accessory Limb Formation in Urodeles

FROG kidney adenocarcinoma implants and normal adult frog kidney implants made subcutaneously on the dorsal radioulnar surface of non-regenerating larval salamander forelimbs cause the host limbs to respond to their presence by forming supernumerary hand-wrist structures. Larval host limbs may on occasion fail to elicit any morphological response[1]. On the other hand, adult salamander host limbs may form: (*a*) an accessory structure comparable with the larval response; (*b*) nothing; (*c*) single or clustered subcutaneous cartilaginous nodules as in Fig. 1 [2,3]. Although these nodules are commonly found in adult host limbs, they had never been produced by larvæ in hundreds of cases assayed.

Serial denervation of larval host limbs, by resection of brachial plexi, begun at 4 days post-implantation, will prevent the production of supernumerary structures[4]. The necessity of innervation for amphibian limb regeneration is well known[5], and in this case the trauma of foreign implant material did not act as a substitute for the influence of the nerve.

The experiments reported here entail denervations of brachial plexi of host limbs, which were delayed 12, 13, 14, 16 and 19 days post-cancer implantation, in 14 larval *Taricha granulosa* and 15 larval *Amblystoma opacum*. The technique has been reported previously in detail[4]. No supernumeraries were recovered in the 12-, 13- and 14-day groups, although three were obtained from the 16- and 19-day groups. The significance of the results is not simply that delayed denervation effects supernumerary development but is in the fact that 5 cases of cartilage nodule formation were obtained in these larval limbs.

These results with the larvæ suggest some ideas regarding this process. They indicate that delayed withdrawal of innervation may be tantamount to removing the growth stimulus to the blastemal mesenchymal cells, cells which are chondrogenically oriented with respect to their developmental potential[6] and, as a consequence of withdrawal of the growth stimulus, these aggregations differentiate into cartilaginous nodules. The common occurrence of nodules in adult host limbs might similarly be explained by co-ordinating certain assumptions and experimental facts to bring about 'theoretical delayed denervations'. The assumptions represent equal and opposite alternatives, and are as follows: (*a*) the terminal innervation pattern of adult urodele limbs may be reduced from the larval condition; a possible extrapolation of the results of Van Stone[7,8], or (*b*) the terminal innervation threshold necessary to support regeneration may be higher in adult than larval limbs, see Singer[5]. Each would have the effect of making it more difficult to obtain innervation sufficient to support accessory morphogenesis in adult host limbs.

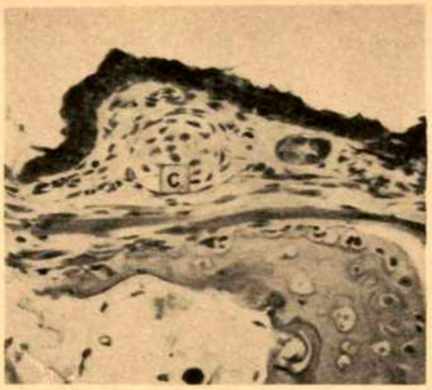

Fig. 1. Longitudinal section of an adult *Triturus viridescens* host limb bearing a subcutaneous accessory cartilage nodule *c*, which was induced to form by a frog kidney adenocarcinoma implant. (× *c*. 120)

Although implant trauma may aid in bringing about dissociation of soft mesodermal host limb tissues to establish a mesenchymal population, these cells will only undergo accumulation into a blastema under the influence of innervation. If the innervation continues to be adequate to support growth and morphogenesis, then a supernumerary will result. If, however, it becomes reduced, subsequent to accumulation and some growth, nodule formation will be obtained.

How, then, can we account for this type of neural reduction in adult host limbs? It seems likely that the implant-induced situation may share with the amputated regenerating limb the possession of a temporarily increased terminal nerve supply[5], and in adult host limbs we have two factors which could combine to bring about a premature return to the normal adult-level. First of all, we know that due to an increased foreign body response in adult Amphibia, the implant will be destroyed more rapidly in adult limbs than in larvæ. Secondly, we know that blastemal formative processes, and indeed all morphogenetic processes, of adult limbs are considerably slower than these same processes during larval limb regeneration. Thus the combination of a more rapid disappearance or at least reduction of the traumatic stimulus and slower blastemal and morphogenetic events could easily account for a premature return to normal innervation patterns with nodules, rather than a supernumerary, the more usual end result.

Previously, I referred to the dissociation of soft, mesodermal tissues of the host limb to provide cells for the future blastema. This statement should be clarified by pointing out that it is usual in implant-induced accessory limb formation that the skeleton of the supernumerary does not articulate with or grow out from the 'mother' limb skeleton. If, however, the traumatic influence bringing about the dissociation of host tissues reaches the skeletal region, then articulation and even some perichondrial outgrowth will be established. (The separateness of perichondrial growth and nodule formation has been clearly pointed out in an experiment by one of my students, J. Andrew Armer. Deviated, cut brachial nerves of the upper forearm of adult *Taricha granulosa* are capable of inducing, in distinct fashion, humeral perichondrial growth *and* nodule formation in soft tissue regions. It should be noted, lest this appear to be contradictory to the thesis of the preceding, that in these instances little or no nerve *growth* could be discerned by silver stain techniques, indicating low-level innervation.) The implant-induced situation might be likened to the regeneration of amputated dehumerized limbs in that the skeleton of the accessory structure usually forms without the aid of adjacent stump or host limb skeleton. The nodules, which now may be considered as having been formed as the result of abortive attempts at supernumerary formation, follow the same pattern in the sense that they appear anatomically separated from the 'mother' limb skeleton.

These investigations were supported in part by a research grant (*C*–2913) from the Research Grants and Fellowships Branch, National Cancer Institute, National Institutes of Health, Bethesda, Maryland.

LAURENS N. RUBEN

Biology Department,
Reed College,
Portland, Oregon.

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Induction of Subcutaneous Nodules in Rabbits with the *SE* Polyoma Virus

THE *SE* polyoma virus grown in mouse embryo cell cultures is capable of inducing a wide spectrum of histologically different neoplasms in hybrid $(C_3Hf \times AKR)F_1$[1] and randomly bred Swiss mice[2], and sarcomas and angiomatous lesions in hamsters[3], and rats[4], if injections are made when the animals are new-born. Tumours in these animals increase in size and number and eventually kill the animals. Contrary to experience with these rodents, new-born rabbits of mongrel breed reacted by developing multiple subcutaneous nodules that later regressed.

The virus was propagated in mouse embryo cell cultures maintained with synthetic medium 199[5] containing 2 per cent horse serum heated to 56° C. for 30 min. The medium was replaced at weekly intervals and only fluid from cultures incubated with the virus for 14 or more days was used for transferring to new cultures or for inoculating animals.

Thirty-two mongrel rabbits less than one day old were injected subcutaneously in the nuchal area with 1 ml. each of undiluted tissue-culture-grown virus of five different sub-lines[6]. 13–64 days later, 19 of the rabbits developed subcutaneous nodules—an incidence of 59 per cent. Most of the nodules were discrete, small and hard; some were large and filled with reddish or amber-coloured fluid. From the largest of such nodules 11 ml. of fluid was removed (Fig. 1).

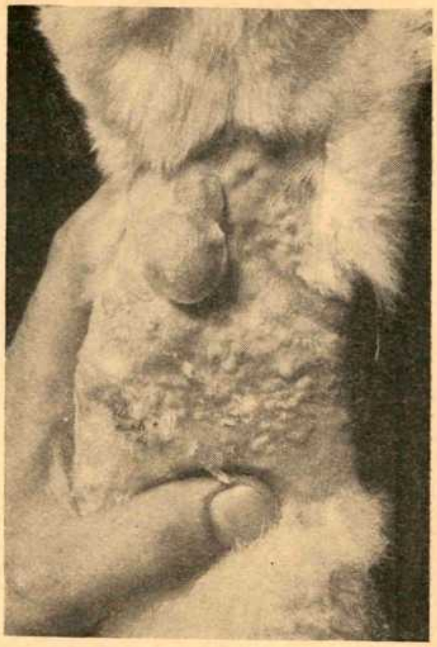

Fig. 1. Multiple subcutaneous nodules induced in a rabbit 56 days of age by injection with *SE* polyoma virus when new-born

A nodule from a rabbit 56 days of age was minced and added to mouse embryo cell cultures and these cultures were maintained and fluid passed to new cell cultures, as has been described[1–4]. New-born hamsters, inoculated with 0·2 ml. each of fluid from second tissue-culture passage of this material, developed neoplasms in the heart and liver when 18 days old. Third tissue-culture passage of fluid from the minced rabbit nodule showed cytopathic changes and fourth tissue-culture passage fluid was used for inoculating a litter of new-born rabbits. 1 ml. of tissue-culture fluid was injected into each rabbit One rabbit developed subcutaneous nodules and died at 13 days of age; another died on the fourteenth day and no nodules could be found. Multiple subcutaneous nodules developed in each of the six remaining rabbits at 25 days of age. The results of the inoculation of rabbits with tissue-culture-grown *SE* polyoma virus are summarized in Table 1. With the exception of the last litter of rabbits that were injected with virus 63 days before, the nodules disappeared when the rabbits were 93–134 days old.

It may be noted that no tumours developed when the animals were inoculated with one virus line

Table 1. INDUCTION OF SUBCUTANEOUS NODULES IN RABBITS INOCULATED SUBCUTANEOUSLY WHEN < 1 DAY OF AGE WITH *SE* POLYOMA VIRUS PROPAGATED IN MOUSE EMBRYO CELL CULTURES

Virus line	Litter No.	No. of rabbits			
		Injected	Dead and no nodules	With nodules	Living and no nodules
3919	1	5	2	2	1
581	2	7	1	0	6
695	3	7	1	6*	0
877	4	3	0	3	0
877	5	2	1	1	0
*R*1517	6	8	1	7	0
Total		32		19 (59%)	

* Tissue from a subcutaneous nodule from one rabbit was used to initiate virus line *R*1517.

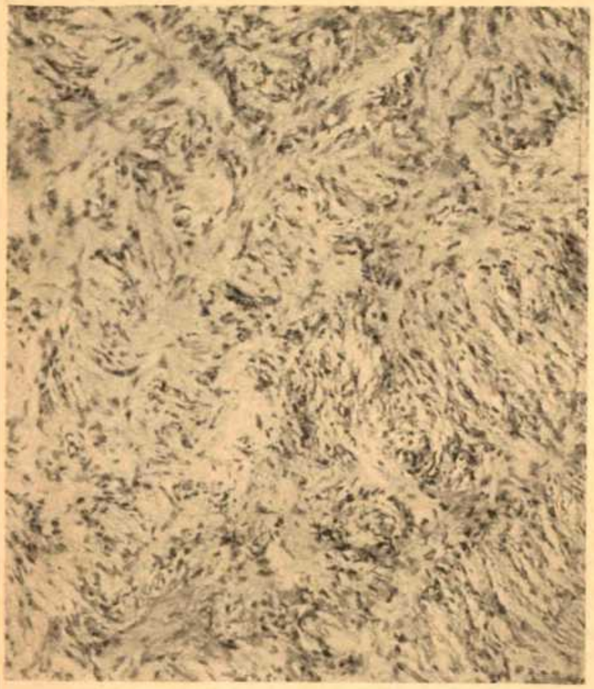

Fig. 2. A cellular area of a subcutaneous nodule. Interdigitating bundles of proliferating fibroblasts may be noted (hæmatoxylin and eosin). (× 135)

preparation. *In vitro* tests[7,8] had not been developed at the time these animals were injected, so it is unknown whether the tissue-culture fluid had a low virus content or whether the rabbits were resistant to the virus.

Nodules were excised from the living rabbits, fixed in Tellyesnicsky's formalin–acetic acid alcohol fluid[9], embedded, sectioned and stained with hæmatoxylin and eosin.

Histologically, the subcutaneous nodules were well circumscribed but not encapsulated (Fig. 2). There were interdigitating bundles of proliferating fibroblasts with plump nuclei seen against a background of pink collagenous tissue. The nodules were more cellular at the periphery and became relatively acellular toward the centre, when a tendency to form collagen was seen with an increase in hæmatoxylin-staining properties of the cells. In areas where cellular detail was sufficient the cells were fusiform with elongated nuclei and fibrillated cytoplasm. Some of the nodules were surrounded by a band of lymphocytes and neutrophils.

These nodules resembled certain fibrous growths in humans. They have been described and characterized by Stout[10] and are generally called fibromatoses. The fibrous growths are of limited growth potential and often regress as did the nodules in the rabbits.

The development of benign rather than malignant growths may be a reflexion of species differences in response of the host to the *SE* polyoma virus. The malignant growths in the different species of animals thus far studied vary. In the mouse, pleomorphic parotid gland tumours are most frequently seen but a variety of other neoplasms are also present. As many as eight histologically different tumours have been induced in one mouse. Multiple sarcomas and angiomatous lesions develop most often in the heart, liver and kidneys of the hamster, and sarcomas or angiomatous lesions occur in the kidneys or subcutaneous tissue of the rat.

(Since these experiments were completed, humoral antibodies for the *SE* polyoma virus have been demonstrated in rabbits after the nodules had regressed. Mice and hamsters bearing virus-induced tumours also develop humoral antibodies[11,12].)

BERNICE E. EDDY
SARAH E. STEWART
RUTH L. KIRSCHSTEIN
RALPH D. YOUNG

Division of Biologics Standards, and
National Cancer Institute,
Department of Health,
Education and Welfare,
U.S. Public Health Service. Dec. 15.

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Freeze-drying of *Harposporium anguillulae* Lohde in its Nematode Host

RECENT attempts to use predacious fungi for the biological control of nematodes have shown the desirability of maintaining adequate supplies of infective material for laboratory and field studies. Many of these fungi can be grown in pure culture on synthetic media, but some grow with difficulty and others only in their hosts.

The freeze-drying of masses of fungus mycelium and spores might be a useful method of maintaining stocks of these obligate parasites. This was attempted using the endozoic fungus *Harposporium anguillulae* Lohde, which was recovered from the sandy soil of a Florida citrus grove infested with the burrowing nematode *Radopholus similis* (Cobb) Thorne. At this time, Aschner's[1] work on the isolation of this fungus in pure culture was not known, and the fungus was carried in living nematodes of the genera *Rhabditis* and *Panagrellus* growing on corn-meal agar plates. Cultures were readily transferred to disease-free nematodes growing on other corn-meal agar plates or swimming in tubes of sterile distilled water. Thousands of infected nematodes were reared in this fashion. The signs of infection appeared after 3–5 weeks at 22° C. Both types of cultures were freeze-dried.

The apparatus consisted of a 'Cenco Hyvac' pump, a 2-l. Dewar flask charged with a mixture of ethylene glycol and dry ice, a 2-l., three-necked flask for freezing the water vapour, and two 500-ml. drying flasks. All fittings were 'Pyrex' brand standard taper glass. The drying was carried out at about − 28° C. and at a vacuum of less than 0·5 mm. of mercury. The agar and fungus-infected nematodes were removed from the Petri dishes, placed in a Waring blendor, some sterile distilled water added and the mass homogenized for 1 min. The viscous mass was diluted with sterile distilled water to make up 100 ml. and 50 ml. were frozen into a thin film on the inner wall of each of the drying flasks, which were immediately evacuated. Drying took 8–10 hr. The resultant fluffy powder was dispensed into a glass jar which was sealed and kept at 22° C. Microscopic examination of the powder revealed large numbers of dead but intact nematodes, and the presence of mycelium and spores of *Harposporium* as well as other fungi.

At weekly intervals 10 mgm. lots of the powder were placed on corn-meal agar plates containing disease-free nematodes. After 3–5 weeks nematodes infected with *Harposporium* were observed, indicating that the viability and virulence of the frozen, dried fungus was not materially reduced. The disease developed in the usual manner and no morphological changes appeared in the fungus after freeze-drying. To date, the dried *Harposporium* powder has retained its activity and virulence for periods ranging up to 4 months from the date of drying.

In view of these results, attempts will be made to freeze-dry other predacious fungi, including those which can be readily grown in pure culture.

WILLIAM A. FEDER
U.S. Department of Agriculture,
Orlando, Florida.

C. L. DUDDINGTON
Biological Laboratories,
The Polytechnic,
Regent Street, London, W.1.

[1] Aschner, M., and Kohn, S., *J. Gen. Microbiol.*, **19**, 182 (1958).

GEOLOGY and PALÆONTOLOGY

How old is the Cambrian System ?

IN a recent contribution in *Nature*, Mayne, Lambert and York[1] have reported the results of age determinations on some British igneous rocks studied in the University of Oxford, and have concluded that the geological time-scale established in the works of Holmes (and of Marble and Belousov) is seriously in error. They claim that the age of 450 million years commonly assigned to Upper Cambrian strata is much too young, and that the base of the Cambrian System should be dated not at 500–520 m.y., but at about 750 m.y. This proposed drastic revision of the most significant date-line in geochronology conflicts somewhat with a large body of recent information to which, apparently, the authors have not had access.

The dating of the Cambrian system has hitherto been based largely upon determinations of the age of Swedish kolm, a mode of calibration which (as the Oxford authors correctly conclude) is very much open to criticism. Kolm is a uranium-rich hydrocarbon occurring within the trilobite sub-zones *Peltura minor* and *Peltura scarabaeoides* in the Upper Cambrian alum shales of Sweden, particularly in Närke and in the Billingen-Falbygden district of Västergötland. It forms lenses, sometimes coalescing into continuous seams, averaging 4 cm. but exceptionally reaching 20 cm. in thickness ; and some twenty unpublished analyses of representative samples made for me when I carried out an economic survey of the Västergötland field in 1945 show an ash content roughly from 19 to 45 per cent, with between 2·91 and 0·51 per cent U_3O_8 in the ash. The oil-shale country-rock carries 0·02–0·04 per cent U_3O_8. The apparent age of the kolm, from determinations by Nier and by Cobb and Kulp[2], is : lead-206/uranium-238, 355–455 m.y. ; lead-207/uranium-235, 420–480 m.y. ; lead-207/lead-206, 650–945 m.y. This discordant pattern of these ages has been attributed by all previous workers to loss of radon and perhaps some loss of lead, notwithstanding an inability to demonstrate a high loss of radon at ordinary temperatures and the manifest incompatibility between hypotheses demanding loss of radon through notional thermal alteration and the presence in the alum shales of a commercial content (4–7 per cent) of oil.

The usefulness of kolm as a geochronological date-line rests wholly upon the hitherto undebated assumption that it acquired its uranium content when the associated trilobites were alive. But there is no evidence to support this premise and much to refute it. Many recent studies have shown that sedimentary hydrocarbons continue to adsorb uranium and other metals from percolating ground-waters long after they were deposited : as an extreme example, a Palæozoic coal may become enriched in uranium from a Mesozoic or Cainozoic radioactive deposit nearby. While, therefore, it seems likely that the kolm originated as a penecontemporaneous segregation of sapropelic gel during the diagenesis of the bituminous sediments, the probability is that for long after lithification it continued to adsorb uranium and perhaps a little lead. For the source of these metals, epigenetic to the kolm, one has to look no further than the surrounding uraniferous oil-shales, in which the metals are syngenetic. As these shales contain old radiogenic lead, the isotopic composition of lead within the kolm will not necessarily be related in any equivalent manner to the uranium there, though because of the extreme simplicity of the regional tectonics there will be but little local variation in the lead – uranium ratios. This interpretation explains the many chemical differences between the kolm and the shale (for example, the much higher sulphur content in the latter, calculated ash-free) and for the first time rationalizes the anomalous age determinations. The most that can be deduced from these figures is that the Upper Cambrian is younger than 650 m.y., the age given by the lowest recorded lead-207/lead-206 ratio.

Fortunately, the claim that "it would be particularly desirable to have unambiguous dates from the Ordovician and Cambrian"[1] has already been answered by Russian investigators[3–5]. For the earlier system a lower limit is set by the age of granite pebbles occurring in a Cambrian basement conglomerate in the Patomskoe uplands of Northern Irkutsk, where there is but a slight hiatus between Upper Proterozoic and Lower Cambrian strata. A granite pebble from this conglomerate gives a potassium/argon age of 464 m.y. determined on the rock, and 566 m.y. determined on mica from the rock. (Another pebble gives a value of 626 m.y., with 763 m.y. on the mica.) An upper limit is set by the Mainsk and Tannuol'sk granites of Tuva, which are intruded into Middle–Upper Cambrian strata and which shed pebbles into overlying Lower Ordovician conglomerates. The Tannu Ola granite is dated by Ivanova and Polevaya, in two potassium/argon determinations on the rock, at 443–448 m.y. Confirmatory determinations are to be found in an argon dating of basalt lava interstratified with reputedly Lower Cambrian (unfossiliferous) sediments in the Volynian series of Belorussia, with an age of 480 m.y., and in a comparable value, 490 m.y., arrived at for an extrusive porphyry interbedded with Lower Cambrian trilobite-bearing strata in Tuva. Even if these latter figures were increased by 20 per cent to bring 'rock-ages' (possibly low through escape of argon from feldspars) into line with 'mica-ages', the Lower Cambrian would not be more than 600 m.y. old.

Additional evidence of quite a novel kind, based on the calcium-40/potassium-40 ratio in sylvite, has just become available from the Radium Institute of Leningrad[6] in a paper which reports the age of a fossiliferous Lower Cambrian potash salt deposit in the Irkutsk region of 620 ± 20 m.y.

A greater age for the Cambrian system is also ruled out by the history of mineralization in Katanga, Belgian Congo[7,8]. Here the uraninite of Shinkolobwe, Kalongwe and Luishya has an age of 600–620 m.y., this being one of the firmest dates in the geological record; and this uranium mineralization is now known to have accompanied the last stages of folding in the Kundelungun geosyncline, at a period which cannot have greatly post-dated the youngest Kundelungun sediments[9,10]. These strata have locally a lithological character potentially very favourable to the preservation of fossils; but a full examination in the course of mining operations has demonstrated that they are devoid of vestiges of life other than stromatolites, micro-algæ and sponge spicules. In other words, at round about 650 m.y. ago a Cambrian fauna had not yet developed.

Recently, Polevaya[3] has published argon datings on twenty-nine post-Proterozoic lavas collected from known geological horizons throughout the stratigraphical column. All but one of her values, without any correction for argon leakage, fit quite well into the Holmes-Marble scale. That loss of argon must have taken place is nevertheless evident from Gerling's extensive studies on the White Sea pegmatites[4], where the average argon leakage from feldspar is 23 per cent, argon datings on micas agreeing excellently with well-established uranium ages. Presumably, therefore, an empirical correction not exceeding 20 per cent must be made in the argon dating of rocks such as liparites, felsites and porphyries when the determination is made on the whole rock and not on separated mica. Such a correction will result in an extension of the Holmes scale going nearly half-way towards the proposals of the Oxford group. On this revised chronology, the base of the Cambrian is dated at about 600 m.y.

C. F. DAVIDSON

University of St. Andrews,
Scotland.
Feb. 3.

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PROF. C. F. DAVIDSON has presented no new evidence free from unambiguous interpretation which would refute our proposed extension of the Holmes *B* time-scale; or indeed on which an alternative scale could be based. The examples which he cites form only a part of a large number of such data which we have considered. We have rejected them because either the stratigraphy of the samples or their measured age is not free from unwarranted assumptions. We have used only samples which are above criticism on these points. We would, however, like to correct Prof. Davidson's remark that we "claim that the base of the Cambrian System should be . . . at about 750 m.y.". In fact, we have avoided using the rather meaningless term 'base of the Cambrian', and we have but estimated, by extrapolation from our oldest measured date at around 500 m.y., that the upper Cambrian "should be closer to 650 m.y.". Prof. Davidson's recapitulation of a possible geochemical history of the kolm emphasizes our conclusion that this material provides a poor calibration point. The pattern of discordancy[1] found for lead ages of the kolm material would not justify his argument that the kolm is younger than 650 m.y. Nevertheless, such an age is not incompatible with an extrapolation of our scale. Considering that the precision of measurement is not better than 5 per cent, this extrapolation could give an age for the top of the Cambrian between 600 and 650 m.y., and clearly this age also depends greatly on the (unknown) length of the Ordovician.

It has been known for a long time that loss of radiogenic argon can occur to a variable extent in some minerals which show no apparent alteration, notably potassium felspar. Thus Prof. Davidson's interpretation of the Russian argon/potassium age values is not justified. This variable loss is often found to be greater than the 23 per cent measured by Gerling for pegmatitic felspar from a particular locality. Its extent is unpredictable *a priori* in any particular sample, although many measurements in the range 300–600 m.y. show a loss greater than 30 per cent. (It is because of this uncertainty that we attach little importance to our interpretation of the age of the Mynydd Mawr microgranite, and the Dubuque felspar.) It is therefore meaningless to use an average percentage loss in order to assess the true age with sufficient precision from whole rock analysis. The whole-rock age-value of lavas and similar very fine-grained rocks may be even more seriously affected on account of the extremely fine grain of the potassium minerals in it. Whole-rock analysis is not yet sufficiently precise for defining a time-scale; and there is certainly no foundation for presuming that "an empirical correction not exceeding 20 per cent must be made in the argon dating of rocks such as liparites, felsites and porphyries, when the determination is made on the whole rock and not on separated mica". In fact, the empirical correction would be particular to each sample, and largely unknown—especially for lavas. Thus the only Russian measurements which are relevant are those on the mica separated from granite pebbles found in Lower Cambrian rocks. Two values are given, 566 m.y. and 763 m.y., and there seems to be no reason to prefer the younger of these as Davidson has done, or indeed, with such disagreement, either of them.

The calcium–potassium method of dating was first used by Inghram *et al.*[2]. The results of its application have shown poor agreement with best-age values, and the analytical errors may be high[3]. Sylvite is an unsuitable mineral to use for dating geological events, since it is subject to recrystallization. We have no knowledge of the geological or analytical details of the Leningrad sample, so it is difficult for us to decide if it fulfils the stringent requirements of a calibration sample. The problem of dating the Ordovician and Cambrian remains.

A close examination of the geology of the Shinkolobwe uranium deposit shows that it is far from being "one of the most certain points in the geologic time scale" (Prof. J. L. Kulp, in Robert, ref. 4, p. 17). Thus, although the age of 630 ± 35 m.y. (as quoted by Robert) is generally agreed to be unusually good, the Shinkolobwe deposit is of no use in defining a time-scale. The precise facts are that the uranium minerals are present in veins of mesothermal type occurring within folded dolomites of the Système Schisto-dolomitique of Katanga. These dolomites and other similarly folded dolomites overlying them in nearby areas contain *Collenia* and *Stromatolithes*, fossils known to exist from the early pre-Cambrian to the Cambro-Ordovician inclusive. The stratigraphic definition of the uranium deposits is therefore of the poorest. The absence of ordinary marine lower-palæozoic faunas is of no weight in this argument, as they are generally unknown from South and Central Africa. We have discussed these remarks on the African samples with Prof. J. L. Kulp, and we learn that his original statement did not refer to the stratigraphy, but to the measured age.

K. I. MAYNE

Clarendon Laboratory, Oxford.

R. ST. J. LAMBERT
D. YORK

Department of Geology and Mineralogy,
Oxford.

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Synthetic Carbonatite Magma

JUDGING from the literature during the past decade, there is a growing interest in problems related to the genesis of carbonatites and associated alkaline igneous rocks. The interest has undoubtedly been fostered by the discovery of large reserves of rare earths in these rocks. Many field geologists believe that carbonatites were emplaced as liquid magmas ; but hitherto there has been no conclusive experimental evidence to support the existence of carbonatite liquids. In fact, from the available experimental evidence it seemed unlikely that such liquids could exist at the low temperatures indicated by field studies. We have recently obtained experimental evidence that simplified carbonatite magmas can exist at moderate temperatures through a wide range of pressures.

Results[1] from a study of the join calcite–water in the ternary system $CaO–CO_2–H_2O$ show that calcite begins to melt at a temperature of 740° C. at 1,000 bars pressure of water vapour. Only a trace of liquid was developed at this temperature, but the amount increased with increasing water content and with increasing temperature. This evidence implied, but did not prove, the existence of carbonatite magmas.

Subsequent studies on the system $CaO–CO_2–H_2O$ have shown that the minimum liquidus temperature at 1,000 bars pressure is 675° C. ± 5° C. At this temperature and pressure, a liquid with the composition calcium oxide 64, carbon dioxide 18, water 18 (weight per cent) is in equilibrium with calcite, portlandite and vapour (almost pure water). At 680° C. and the same pressure, a liquid develops on the calcium oxide side of the $Ca(OH)_2–CaCO_3$ join ; this is in equilibrium with calcite, portlandite and calcium oxide and has a composition calcium oxide 68, carbon dioxide 19, water 13 (weight per cent). At 685° C. the two liquid fields coalesce and at still higher temperatures the range of composition of the liquid field increases. The minimum liquidus temperature in the system has been determined for a range of pressures. At 500 bars the temperature is 680° C., and at 4,000 bars it is lowered to 640° C. At pressures lower than 50 bars, the minimum liquidus temperature decreases, and at 27 bars pressure the appropriate composition is completely liquid at 665° C. The high melting temperature of calcite is therefore lowered markedly by the addition of calcium oxide and water under pressure. The low-temperature liquid may be regarded as a simplified carbonatite magma. Although calcite is generally the dominant mineral in carbonatites, dolomite is frequently an important constituent, while apatite and mica are constant accessories. Experiments are under way to find the effect of additional components (such as magnesium oxide, phosphorus pentoxide, silicon dioxide and alkalis) on the minimum liquidus temperature in the ternary system. Solubility determinations are also being made to see how the solubility of calcite varies with increasing content of carbon dioxide in the aqueous vapour phase. Many geologists believe that a high-temperature vapour, consisting of water and carbon dioxide, is able to dissolve large amounts of calcium oxide, magnesium oxide, ferrous oxide, etc.

Detailed results of these studies will be published in due course, but we take this opportunity of presenting these facts now because they will be of interest to geologists working on carbonatites.

P. J. WYLLIE
O. F. TUTTLE

Department of Geophysics and Geochemistry,
College of Mineral Industries,
Pennsylvania State University,
University Park, Pa.
Jan. 27.

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Manganese in Modern and Fossil Gastropod Shells

VERY little work has been done on manganese concentrations in shell material and particularly in gastropod shells, although Doring in Vinogradov's book[1] reported several analyses and found from 0·1 to 0·0001 per cent manganese by weight in gastropod shells. Krinsley and Bieri[2] have determined manganese in the shells of modern and fossil pteropods.

This trace element was examined in modern and fossil shells to determine whether burial and subsequent diagenesis might have altered the original material.

Eighty modern and fossil shells of *Olivella biplicata* (Sowerby), 89 of *Tegula funebralis* (A. Adams) and

Table 1

Locality	*Olivella*			*Tegula*			*Fissurella*		
	Mn (p.p.m.) $\bar{x}$	Ar. (per cent) $\bar{x}$	No. of specimens	Mn (p.p.m.) $\bar{x}$	Ar. (per cent) $\bar{x}$	No. of specimens	Mn (p.p.m.) $\bar{x}$	Ar. (per cent) $\bar{x}$	No. of specimens
MODERN ANIMALS									
A La Jolla, California 32° 52′ N., 117° 16′ W.	4	100	10	5	54	10	7	66	10
B La Jolla, California 32° 52′ N., 117° 16′ W.	< 4	100	10	6	64	10	< 4	60	10
C Palos Verdes, California 33° 47′ N., 118° 25′ W.	5	100	10	4	92	10	6	61	10
D Palos Verdes, California 33° 47′ N., 118° 25′ W.				6	67	10			
E Pismo Beach, California 35° 10′ N., 120° 40′ W.	< 4	100	9	4	75	9	< 4	53	10
F Neah Bay, Washington 48° 40′ N., 124° 40′ W.	< 4	100	10	5	65	10			
FOSSILS									
X Upper Pleistocene. Ocean Beach, California 32° 42′ N., 117° 16′ W.	8	100	10	13	70	10	5	57	9
Y Middle Pleistocene Pacific Beach, California 32° 48′ N., 117° 16′ W.	4	100	10	17	87	10			
Z Middle Pleistocene San Pedro, California 33° 45′ N., 118° 17′ W.	11	100	10	17	81	10			

Localities *Y* and *Z* represent equivalent ages.

49 of *Fissurella volcano* Reeve were analysed for manganese with a 21-ft. grating spectrograph[3]. Aragonite percentages were determined with a North American Phillips X-ray diffraction unit, using the method reported by Chave[4] with modification. (Note that each locality listed in Table 1 represents the mean of approximately ten specimens analysed in duplicate.) The specimens were carefully hand-cleaned to eliminate any material on external and internal shell surfaces. The error involved in the spectrographic analyses was ± 20 per cent of the amount present.

Since manganese, because of its size, will theoretically fit more readily into the calcite than the aragonite structure, one would expect to find more manganese in calcitic shells than aragonitic ones. However, the amount of manganese in the shell material analysed is small, and the results are inconclusive (Table 1) with respect to modern specimens.

Post-depositional changes have increased the amount of manganese in some of the fossil shells (Table 1). *Tegula* and *Olivella* fossil shells have more manganese than modern shells with the exception of *Olivella* at locality *Y*, which has the same amount as modern specimens. *Fissurella* modern and fossil shells contain the same concentrations of manganese. One might at first suspect that the larger manganese concentrations in some of the fossils were due to surface contamination from the sediment matrix, even though the specimens were carefully cleaned. However, this is shown to be unlikely by the 19 analyses of fossil *Fissurella* at locality *X* and *Olivella* at locality *Y*, which do not differ from the modern shells.

No recrystallization of shell material has occurred in *Olivella* as indicated by lack of change in calcite–aragonite ratios in the fossils. Probably little or no recrystallization has occurred in *Tegula*; the aragonite percentages in fossil *Tegula* are higher than those in modern forms. Recrystallization always lowers the aragonite content.

Two groups of *Tegula* specimens were selected at Palos Verdes, California (Table 1). Group *D* was collected alive on rocks at the edge of the beach and killed, while group *C* was collected from shell heaps on the beach. All other *Tegula* specimens were collected alive. The age of group *C* is impossible to determine; but the shells have undoubtedly been subjected to alternate wetting and drying after death or may even have been under water for some time. In any event, no increase in manganese has occurred in group *C*, indicating that the processes which have added manganese to the shells probably occur largely after burial.

If the mean manganese content at a given fossil locality in a particular species is higher than in modern specimens, then the manganese variation in that population is found to be correspondingly high. Manganese would be expected to accumulate at different rates in individual fossils and thereby increase variation in the fossil populations. This increased variation, which is not characteristic of any of the modern specimens, is another indication that addition of manganese has occurred after burial. If no alteration of the shell material at a particular fossil locality has occurred, fossil variation will approximate modern variation.

The increase in manganese in some of the fossils is due partially to diffusion from the surrounding sediments into the shell material (assuming that the fossils originally had approximately the same composition as the modern animals). The size of the shell crystals, the differing construction of shell material in the various species examined[5], chance contact with other shells of higher manganese content and, more important, diagenetic conditions at a particular locality, probably determine whether increase of manganese in fossil shells has occurred. It is impossible at present to separate these factors; but diffusion experiments and a more thorough knowledge of the construction of shell material should help solve the problem.

DAVID KRINSLEY

Department of Geology,
Queens College,
Flushing, New York.
Jan. 20.

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STATISTICS

Matching and Prediction in the Social Sciences

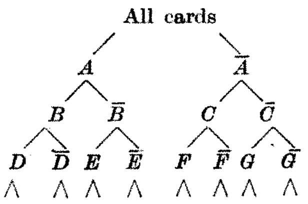
Matching processes are constantly in use in the social sciences. Often their use is explicit, as in studies of the relative effects of different experiences or procedures. In other cases they are implicit, as in the use of specific controls for the selection of consumer panels or in quota surveys. They are also implicit in many extrapolation processes. Even so, the variables used for matching processes are in most cases of non-empirical origin, and are selected on the basis of either custom or hunch. The result may well be that the matching is inadequate, sometimes completely so.

Empirical procedures can, of course, be used. The principle of the empirical method is that, for a variable to be relevant in matching, it must be correlated to some appreciable degree with whatever it is that is being studied (for example, a specific attitude, buying behaviour). If all the proposed matching variables are arranged in a correlation matrix, multiple correlation methods[1] can be used to select from them that combination of variables which gives the highest multiple correlation with whatever is being studied (that is, the criterion). These variables are then used as the basis for matching, and this usually proceeds through a form of prediction, perhaps involving the use of a regression equation.

This sort of work is, however, most arduous. Matching on the empirical principle requires that each fresh criterion must have its own set of matching variables. Also, the development of a correlation matrix is specially inadequate where many of the available variables involve a 'yes' or 'no' response.

Several years ago I developed a technique of the latter kind and have used it in various inquiries[2,3]. But a much simpler and more adequate technique can be used, and I have applied this in more recent studies[4].

The method involves matching on the principle of simple classification. Suppose the matching is being done to allow the study of the effect of different stimuli on criterion X. The following steps are involved. (*a*) Numerous proposed matching variables are included in the testing phase. (*b*) Each of them is then analysed against score on criterion X, and that one which has the greatest association with, or power to predict, the criterion score is selected as the first-stage predictor (or matching variable). This variable will then serve to split the record cards of the informants into at least two groups, A and $\bar{A}$. (*c*) Next, this process is repeated with all the cards in pack A, and the variable with the highest predictive power is selected as the second-stage predictor within that pack. Call this one B, and let it split the A pack into groups B and $\bar{B}$. (*d*) Now repeat the process with pack $\bar{A}$ and select the best predictor within that pack. Call this C and let it split $\bar{A}$ into C and $\bar{C}$.



The vital point here is that the second-stage predictor in pack A is not necessarily the same as the second-stage predictor in pack $\bar{A}$. In other words, what matters in one group may well differ from what matters in another. Multiple correlation procedures do not allow for this. (*e*) The splitting process is continued, so far as it can be taken, on the pattern shown above. The final set of categories or sub-groups defines the matching composite.

There is no need to employ only two-way splits of card packs. Three or more splits can be used at any stage.

The device for selecting any one predictor in the composite is a simplified version of the chi square calculation. The cards are analysed on a four-cell system: 'high' versus 'low' scores on the criterion test and 'yes' versus 'no' on the item being tested as a possible matching variable. The matching power of this trial item is given in the form of a direct count of the number of cases in the four cells which deviate from what might be expected on a null hypothesis (that is, a hypothesis of no association or predictive power at all). Matching power so derived is more accurate than when gauged from most correlation coefficients. It is on the basis of this selection procedure that the final matching composite is built up as described above.

The use of the selected composite of matching variables to achieve matching is also very straightforward. Suppose that in the study of criterion X (for example, buying behaviour), the record cards for sample I are to be matched to those for sample II. (*a*) Split each sample into sub-groups on the above pattern. Suppose this yields 40 sub-groups (for each sample). (*b*) Now equate the number of cards in each sub-group (in the sample I pack) to its equivalent sub-group in the sample II pack. This can be done on random principles, but the equating process must not involve throwing out more than a few record cards. Discarding of cards can be all but avoided if the device is used of multiplying all the pack II sub-groups by a constant sufficient to raise their numbers well above the general level of the numbers in pack I. This constant may be 2 or 3 or 4 depending on the relative sizes of the two samples. (*c*) Alternatively, the average criterion score for each sub-group in pack I can be weighted (separately) by the number of cards in the equivalent sub-group in pack II. In this way, there need be no loss of cards at all, though slight statistical problems may arise.

I have been using the 'classification system' of matching since 1957. There are points at which it is similar to the technique described in the recent communication by Williams and Lance[5].

W. A. Belson

Research Techniques Unit,
London School of Economics and
Political Science,
Houghton Street,
London, W.C.2.

Jan. 8.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 16

Royal Institution, Library Circle (at 21 Albemarle Street. London, W.1), at 5.30 p.m.—Four short talks on "Books from the R.I. Library".

Society of Chemical Industry, Pesticides Group (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Mr. J. E. H. Grose: "Problems in Stomoxys Research in East Africa".

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6 p.m.—Mr. G. O. McLean: "Something for Nothing? Heat Pump Achievements".

Northampton College of Advanced Technology (at St. John Street, London, E.C.1), at 6 p.m.—Dr. Dimitri Riabouchinsky (L'Académie des Sciences de l'Institut de France): "The Hydraulic Analogy and Air Resistance".

Institute of Metal Finishing (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 6.15 p.m. —Prof. Ernst Raub: "Hydrogen Content of Electro-Deposits".

Tuesday, March 17

Institution of Chemical Engineers (at Church House, Westminster, London, S.W.1), at 9.30 a.m.—Spring Meeting.

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. G. Phillips: Informal lecture on "Electrical Uses of Atomic Spin".

Plastics Institute, London and District Section (at the Wellcome Building, 183–193 Euston Road, London, N.W.1), at 6.30 p.m.—Mr. D. S. Mahon: "Plastics—Why should I Worry?" (Chairman's Lecture).

Tuesday, March 17—Thursday, March 19

Oil and Colour Chemists' Association (at the Royal Horticultural Society's New Hall, Greycoat and Elverton Streets, London, S.W.1)—Eleventh Technical Exhibition.*

Tuesday, March 17—Saturday, March 21

Eighth Electrical Engineers (A.S.E.E.) Exhibition (at Earls Court, London).

Wednesday, March 18

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. B. A. Southgate: "A Study of the Pollution of the Thames Estuary".

Physical Society, Colour Group (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3 p.m.—Mr. A. W. S. Tarrant: "How Reproducible are Standard Illuminants?". 4.45 p.m.—Discussion on "Illuminants B and C" introduced by Mr. J. Guild and Mr. F. Warburton.

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. B. C. King: "Problems of Pre-Cambrian Correlation in Western and Central Uganda".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. H. H. Lamb: "The Southern Westerlies—a Preliminary Survey; Main Characteristics and Apparent Associations"; Mr. W. T. Roach and Mr. R. M. Goody: "Absorption and Emission in the Atmospheric Window from 770 to 1,250 $cm.^{-1}$".

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Mr. W. E. Thomson: "ERNIE—a Mathematical and Statistical Analysis".

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. R. W. Parnell: "Physique and Family Structure".*

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. C. W. Oatley: "New Amplifying Techniques".

Royal Institute of Chemistry; The Classical Association; and the Haldane Society (at the William Beveridge Hall, Senate House, University of London, W.C.1), at 5.30 p.m.—Debate on the motion "That the Education of our Future Rulers should be Primarily in the Sciences rather than in the Humanities". Chairman: Prof. Sir Cyril Hinshelwood, F.R.S. Proposer, Sir Alexander Fleck, K.B.E., F.R.S. Opposer: Prof. B. Farrington. Seconder for the Motion: Prof. A. R. Ubbelhode, F.R.S. Seconder against the Motion: Prof. W. Beare.

University College, Department of Pharmacology (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Valy Menkin (Temple University, Philadelphia): "Biochemical Mechanisms Involved in Inflammation".*

British Computer Society (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 6.15 p.m. —Mr. C. E. G. Bailey: "An Approach to Learning and Teaching Machines".

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. A. Keynes: "Economic Aspects of Corrosion".

Thursday, March 19

Physical Society, Optical Group (in the Physics Department, Imperial College, London, S.W.7), at 2.30 p.m.—18th Annual General Meeting.

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Meeting for Election of Fellows. 4.30 p.m.—Mr. D. Brennan and Mr. P. C. Fletcher: "The Atomization of Hydrogen on Tungsten"; Mr. G. A. Gilbert: "Sedimentation and Electrophoresis of Interacting Substances. 1: Idealized Boundary Shape for a Single Substance Aggregating Reversibly".

Institution of Mining and Metallurgy (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. F. A. Williams: "Recovery of Semiheavy Minerals in Jigs"; Mr. D. C. Shelton: "Santa Barbara Mill, Chihuahua, Mexico".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. Kathleen I. M. Chesters: "Ecological Conditions in the Early Tertiary of Great Britain"; Prof. Tom Harris F.R.S.: "The Possibilities of Palæo-ecology in the Jurassic"; Dr. William S. Lacey: "Some Aspects of Palæo-ecology in the Karroo of Rhodesia and Nyasaland".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. B. Huppert: "Composition-series of Finite Groups".

Royal Aeronautical Society (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. E. C. Cornford: "Long Range Missiles".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. D. A. Dowdeswell: "Slag for Roadmaking".

British Institution of Radio Engineers, Medical Electronics Group (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. H. Wolff: "Instrumentation in Field Physiology".

Royal Society of Tropical Medicine and Hygiene (at the Royal Army Medical College, Millbank, London, S.W.1), at 7.30 p.m. —Laboratory Meeting. Chairman: Sir John Boyd, O.B.E., F.R.S.

British Institute of Radiology, incorporated with the Rontgen Society (at 32 Welbeck Street, London, W.1), at 8 p.m.—Mr. D. A. Wilson: "Some Health and Safety Problems".

Thursday, March 19—Friday, March 20

Physical Society (at Birkbeck College, Malet Street, London, W.C.1), at 9.30 a.m. daily—Symposium on "Fluctuation Phenomena and Stochastic Processes".

Society of Chemical Industry, London Section (in the Beveridge Hall, Senate House, University of London, W.C.1), at 2.15 p.m. on Thursday and 9.30 a.m. on Friday—Symposium on "Costing in the Chemical Indnstry".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2)—Convention on "Stereophonic Sound Recording, Reproduction and Broadcasting".

National Association for Mental Health (at the Assembly Hall, Church House, Westminster, London, S.W.1), at 10 a.m. daily—Conference on "The Place of Work in the Treatment of Mental Disorder".

Friday, March 20

Society for Water Treatment and Examination (in the Library, Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 9.30 a.m.—Seventh Annual General Meeting.

Biochemical Society (in the Department of Biochemistry, The University, South Parks Road, Oxford), at 11 a.m.—381st Meeting.

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Discussion of geophysical papers received during the Session. Chairman: Dr. R. Stoneley, F.R.S. Speakers will include Dr. A. H. Cook, Mr. C. Jones and Dr. R. L. G. Gilbert.*

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Captain F. J. Wylie, R.N.: "The Impact of Radar on the Rules of the Road at Sea".

Institution of Electrical Engineers (joint meeting with the Institutions of Civil and of Mechanical Engineers, at the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1), at 6 p.m.—Sir Harold Plant: Fifth Graham Clark Lecture.

Institution of Electronics (in the Assembly Hall of the University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Mr. L. E. A. Bourn: "The Electronic Organ".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Air Commodore W. K. Stewart: "Man as a Controller of Flight Vehicles".

Saturday, March 21

Linnean Society of London, Palæobotany Group (at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Discussion on certain of the Proposals concerning the International Code of Botanical Nomenclature.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Biochemistry—The Registrar, The Manchester College of Science and Technology, Manchester 1 (March 28).

Chair of Forensic Medicine; and Chair of Bacteriology in the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Ceylon, March 31).

Assistant Lecturers (2) in Pure Mathematics; Assistant Lecturers or Lecturers (3) in Applied Mathematics; a Lecturer in Statistics; an Assistant Lecturer (with special interests in experimental morphology or physiological ecology) in Botany; Junior Research Fellows (2) (with special interests in organic or inorganic chemistry) in Chemistry; a Lecturer (medically qualified) in Medical Genetics; and a Lecturer in Biochemistry—The Registrar, The University, Sheffield (April 4).

Assistant Lecturers or Lecturers in Pure Mathematics (two appointments); Physics, Civil Engineering, Mechanical Engineering, and Chemical Engineering: and an Assistant Lecturer in Geology—The Registrar, University College, Singleton Park, Swansea (April 4).

Research Assistant in the Department of Botany, to assist with research on aspects of nitrogen metabolism being conducted by Dr. G. E. Fogg and Dr. L. Fowden—The Secretary, University College, Gower Street, London, W.C.1 (April 4).

Senior Lecturer in Physics—The Registrar, The University, Sheffield (April 4).

Imperial Chemical Industries Fellows (preferably under 29 years of age) at Durham or Newcastle, for research in Engineering, Chemistry, Physics and allied subjects, including the biological application of chemistry—The Registrar, University Office, 46 North Bailey, Durham (April 6).

Research Fellow (with a Ph.D. degree or equivalent research experience) in the Chemistry Department, for work on fundamental aspects of heterogeneous catalysis, in collaboration with Dr. G. C. Bond—The Professor of Chemistry, The University, Hull (April 6).

Research Fellow (with a Ph.D. degree or equivalent research experience) in the Chemistry Department, for work on the kinetics of gaseous oxidation reactions, in collaboration with Dr. R. R. Baldwin—The Professor of Chemistry, The University, Hull (April 6).

Chair of Philosophy—The Registrar, University Office, 46 North Bailey, Durham (April 9).

Research Fellow (with an interest in physical-organic chemistry, and some postgraduate experience in preparative chemistry) in the Department of Chemistry—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 10).

Lecturer in Mathematics—The Secretary, The University, Aberdeen (April 11).

Lecturer (with good academic qualifications) in Botany—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 13).

Lecturer in Physiology—The Secretary, The Queen's University, Belfast (April 15).

Lecturer in the Department of Metallurgy, to teach and carry out research in Physical Metallurgy—The Registrar, The University, Liverpool (April 18).

Lecturer or Assistant Lecturer in Experimental or Theoretical Physics at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 18).

Assistant Lecturer (honours graduate) in Chemistry—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (April 20).

Reader or Senior Lecturer in Soil Science; a Senior Lecturer or Lecturer in Horticulture; and a Senior Lecturer or Lecturer in Farm Mechanization and Irrigation at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 20).

Assistant Director (with a good degree or equivalent qualification in a biological science, experience of annual and perennial crops, and preferably a knowledge of foreign languages and experience in editing scientific publications) of the Bureau of Horticulture and Plantation Crops, East Malling Research Station, East Malling, Maidstone, Kent—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (June 14).

Assistant Master to teach Mathematics up to University Scholarship level—The Headmaster, Tonbridge School, Tonbridge, Kent.

Head of the Chemistry Department—The Headmaster, Gordonstoun School, Elgin.

Master (not over 30, with at least a second-class honours degree) to teach Physics up to Lower Sixth form standard—The Headmaster, King's College School, Wimbledon, S.W.19.

Scientific Officer or Senior Scientific Officer (with a good honours degree or equivalent with training preferably in both physiology and physics), for research in the energy metabolism of farm animals using direct calorimetry—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

Seed Mycologist (with a degree in botany, and preferably some postgraduate training) on the staff of the Official Seed Testing Station for England and Wales—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Senior Scientific/Scientific Officer (with a first- or second-class honours degree in physics or physical chemistry or equivalent qualifications), to carry out research concerned with the development and application of solid-state electronic optical devices—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 2174/34.

Soil Chemist (with an honours degree in chemistry, or in natural science including chemistry, and at least two years postgraduate training or experience as a Soil Chemist) at the West African Institute for Oil Palm Research, Nigeria, for the study and analysis of soil types with a view to improving soil conditions—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/199/016.

Statistician (with a good honours degree and preferably experience or an interest in agricultural experimentation) in the Department of Biometrics—The Secretary, The Grassland Research Institute, Hurley, near Maidenhead, Berks.

Technician or Junior Technician (G.C.E. (A)' standard), for biochemical and histological research—The Professor of Pathology, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2, marking envelope "Path. Technician".

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 687, Vol. 242 (1 January, 1959): Observations on the Solenacea with Reasons for Excluding the Family Glaucomyidae. By G. Owen. Pp. 59–97. 12*s*. No. 688, Vol. 242 (1 January, 1959): A Study of Variation and Relative Growth in the Blastoid *Orbitremites*. By K. A. Joysey. Pp. 99–125. 10*s*. (London: Royal Society, 1959.) [11

Observations Made at the Royal Observatory, Greenwich, in the year 1957 in Astronomy, Magnetism and Meteorology. Pp. 442. (London: H.M. Stationery Office, 1958.) 117*s*. 6*d*. net. [11

The Health of the School Child: Fifty years of the School Health Service. (Report of the Chief Medical Officer of the Ministry of Education for the years 1956 and 1957.) Pp. i+220+12 plates. (London: H.M. Stationery Office, 1958.) 10*s*. 6*d*. net. [191

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 110: Diseases and Pests of Tomatoes. Pp. 14. (Belfast: Ministry of Agriculture, 1958.) [191

Planning, Vol. 25, No. 430: Scientific and Engineering Manpower Survey. By Richard Fort, M.P. Pp. 1–128. (London: Political and Economic Planning, 1959.) 2*s*. 6*d*. [191

Northampton College of Advanced Technology. Report of the Governing Body for the year 1957–58. Pp. 18. (London: Northampton College of Advanced Technology, 1959.) [191

The Colombo Plan for Co-operative Economic Development in South and South-East Asia—Seventh Annual Report of the Consultative Committee, Seattle, Washington, November 1958. Pp. 192. (Cmnd. 610.) (London: H.M. Stationery Office, 1958.) 8*s*. net. [191

National Parks and Access to the Countryside Act. Ninth Report of the National Parks Commission for the year ending September 30, 1958. Pp. iv+79+8 plates. (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net. [191

Other Countries

The Transvaal Ape-Man—Bearing Cave Deposits. By C. K. Brain. With an Appendix by R. F. Ewer. (Transvaal Museum Memoir No. 11.) Pp. viii+131. (Pretoria: Transvaal Museum, 1958.) [11

Rijkslandbouwhogeschool, Gent. Tiende International Symposium over Fytofarmacie en Fytiatrie, 6–7, Mei, 1958. (Overdruk uit Mededelingen van de Landbouwhogeschool en de Opzoekingsstations van de Staat te Gent, 1958, Deel XXIII, No. 3–4.) Pp. viii+561-1056. (Gent: Rijkslandbouwhogeschool, 1958.) [11

Institut Royal Meteorologique de Belgique. Publications Serie A, No. 7: Realisation du Centre de Physique du Globe a Dourbes. Par Prof. Edm. Lahaye. Pp. 104. (Bruxelles: Institut Royale Meteorologique de Belgique, 1958.) [11

Conseil International des Unions Scientifiques. Union Géodésique et Géophysique Internationale. Association de Séismologie et de Physique de l'Intérieur de la Terre. Comptes Rendus des Séances de la Onzième Conférence Réunie a Toronto du 3 au 14 Septembre 1957. (Comptes Rendus No. 12.) Pp. 448. (Strasbourg: Bureau Central International de Séismologie, 1958.) [191

Organisation for European Economic Co-operation. Third Report on the Agricultural Policies in Europe and North America. (Report prepared by the Ministerial Committee for Agriculture and Food.) Pp. 467. (Paris: Organisation for European Economic Co-operation; London: H.M. Stationery Office, 1958.) 1,400 francs; 24*s*. [191

Rockefeller Foundation. The President's Review from the Rockefeller Foundation Annual Report, 1957. Pp. viii+75+31 plates. (New York: Rockefeller Foundation, 1958.) [191

Caracteristicas de Alguns Oleos Essencias Brasileiros. By Waldemar Raoul. Pp. 24. (Rio de Janeiro: Ministerio do Trabalho, Indistria e Commercio, Instituto Nacional de Tecnologia, 1957.) [191

World Health Organisation. Technical Report Series. No. 149: Joint FAO/WHO Expert Committee on Nutrition—Fifth Report. Pp. 55. 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. No. 153: Insect Resistance and Vector Control—Eighth Report of the Expert Committee on Insecticides. Pp. 67. 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. No. 157: Air Pollution: Fifth Report of the Expert Committee on Environmental Sanitation. Pp. 26. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. No. 158: Expert Committee on Medical Rehabilitation—First Report. Pp. 52. 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) [191

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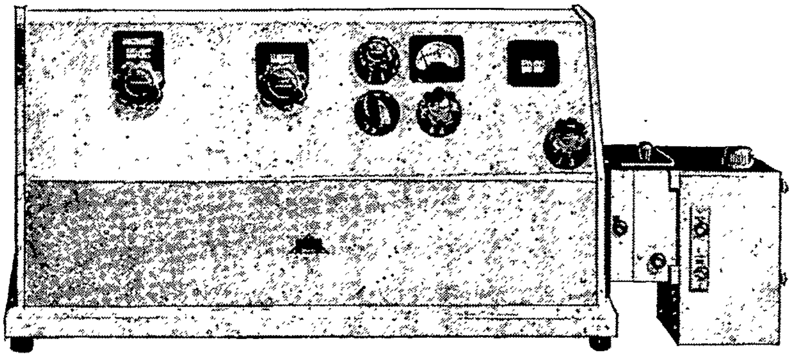

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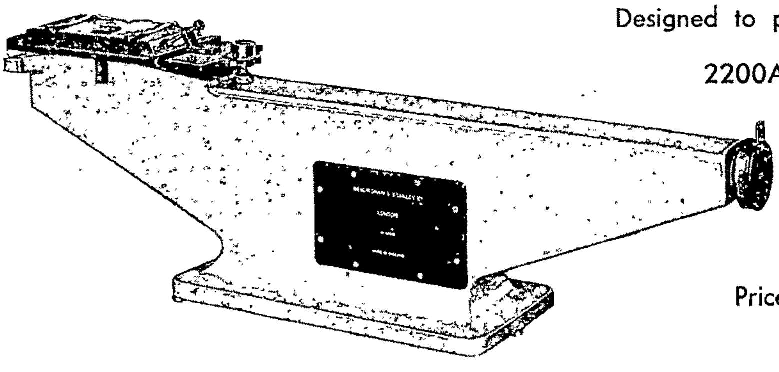

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SCIENTIFIC CO-OPERATION IN THE COMMONWEALTH

THE U.S. National Academy of Science has undertaken, at the request of International Co-operation Administration, a study of the way in which the latter can most effectively use science and technology in technical assistance programmes in Africa south of the Sahara and north of the Union of South Africa. The broadening basis of co-operation is a theme of the latest annual report of the Rockefeller Foundation, and the increasing interest of the United States in scientific and technical work in Africa and in other relatively under-developed parts of the world has already been welcomed by Lord Hailsham. Quite apart from the Anglo-American agreement in the autumn of 1957 on scientific and technical co-operation, especially in defence, the general shortage of trained man-power has given scientific and technical co-operation to-day an importance even greater than it possessed before the Second World War. This is only partly due to the development of the technical assistance programmes both under the Colombo Plan and under the United Nations. It arises from the growing scale, complexity and costliness of scientific and technological research and from the growth, during and after that War, of obstacles to the interchange of knowledge and to the free discussion of scientific and technical work, as a result of political differences or real or imaginary considerations of national security.

Free movement of scientists and technologists from one country to another, both within and outside the British Commonwealth of Nations, has never been more desirable, both from the point of view of scientific and technical advance and from its contribution to international understanding and goodwill. Again, the free exchange of knowledge is increasingly essential from the economic point of view, while the recent international conference on scientific information at Washington indicated the impracticability of dealing with the immense volume of advancing knowledge except on a basis of international co-operation. Only international co-operation can enable mankind to reap the full benefits which nuclear power, radar, jet propulsion, radio astronomy and other advances have placed within our reach.

The address on scientific co-operation within the British Commonwealth which H.R.H. the Duke of Edinburgh delivered in Karachi on February 7 at the annual meeting of the Pakistan Association for the Advancement of Science (see *Nature* of February 14, p. 425) is thus particularly appropriate, for it is from such co-operation that any wider scientific co-operation of the United Kingdom should start. Following a lucid summary of the development of scientific co-operation within the Commonwealth, the Duke affirmed his conviction that the whole Commonwealth would benefit greatly from a larger movement of scientists, whether as students, research workers, teachers, or members of scientific expeditions, and he was concerned about how this could be encouraged in practice. Rightly he emphasized at the outset that informal co-operation arising out of personal and informal contacts between individual scientists is of supreme importance and even in volume probably exceeds organized co-operation.

That point needs to be kept in mind before proposing a new or elaborate organization for co-operation. The first essential is to secure the conditions which permit and encourage mobility and interchange in general, to remove the obstacles to personal contact, to free discussion and to the communication of ideas and knowledge. If the political and financial conditions are appropriate, even informal effort will go far to secure what is essential, and one important outcome of the new programme of Commonwealth scholarships and fellowships adopted in principle at the Montreal Commonwealth Trade and Economic Conference last September should be to foster such mobility; though it will be recalled that the conference which this year is to formulate the programme is also to review existing arrangements for co-operation between Commonwealth countries in the field of education generally.

The Duke of Edinburgh pointed out that the present pattern of scientific co-operation within the Commonwealth has five aspects: the regular discussion of general scientific problems and of problems particular to the Commonwealth; the discussion of problems of the administration of science and research; the regular exchange of scientific information; the movement of scientists; and technical help and advice. The last is particularly fostered under the Colombo Plan, the Scientific Council for Africa South of the Sahara, the Technical Assistance Administration of the United Nations, the expanded programme of technical assistance, as well as the 'Point Four' programme of the United States. The Colonial research reports give some idea of the amount of scientific co-operation that already takes place within the British Commonwealth. The latest report on the Colombo Plan for co-operative economic development in south and south-east Asia gives an impressive picture of the Commonwealth effort in technical assistance in that area alone. Besides the £3·71 million and 317 experts provided by the United Kingdom under the Technical Co-operation Scheme from its inception up to June 30, 1958, Australia has provided £2·8 million and 284 experts as well as 2,286 training awards; Canada, 5·2 million dollars, 126 experts and has trained 1,005 Fellows and scholars; while New Zealand has provided £897,000, 89 experts and training for 549 persons. India has provided training for 886 persons, while by the end of June 1958 member countries had contributed 6,952 scholarships and training awards. About half the total technical assistance expenditure under the Colombo Plan has been devoted to study and training courses, and there is now a marked tendency towards more rapid development of technical training facilities in the Colombo Plan area.

The cumulative effect of these developments must be considerable, and there is to be added to it that of the United States' own programmes of expanded aid, of the United Nations technical assistance programmes and that specifically provided to the dependent territories under Colonial Development and Welfare Schemes. The Commonwealth scholarship scheme proposed at Montreal last September will in due course add to the flow, and there are also the activities of commercial firms as well as of the Rockefeller Foundation, the Nuffield Trust, the Fulbright Programme, the British Council and the Marshall Aid Commemoration Scholarships. All these also encourage mobility, and the movement of students, scientists and technologists from one country to another.

Probably the most important point is to encourage initiative and make it relatively easy for those who wish to do so to move from one country to another, widening their professional experience and exchanging ideas and techniques. Professional bodies have a contribution to make, as have the universities and other educational institutions, but a major responsibility must rest on the Governments even in respect of unorganized and private mobility. Primarily, Government policy will largely determine whether or not financial and other conditions, including pension schemes, are weighted so as to discourage the mobility which is as desirable professionally and from the point of view of science and technology as it is from that of international understanding.

From this point of view the extension of the system of British Commonwealth scientific liaison officers suggested by the Duke of Edinburgh might be as useful as in relation to co-operation in research which he appeared to have primarily in mind, particularly if the system of scientific attachés were extended at the same time. Any increase in the effectiveness with which representations can be made to governments about the conditions which determine the successful prosecution of scientific work are highly desirable. Too often, failure in Government circles, and frequently, too, at lower levels among officials, to appreciate these factors leads to waste of effort and frustration and can even defeat the whole purpose of policies intended to extend scientific or technical activities. The status given to such scientific attachés is important not simply from the point of view of attracting men of the appropriate ability but also from that of the weight likely to be attached to their advice and representations.

The regular exchange of scientific information is a highly technical and complex problem on which the Duke did not touch and which was indeed not fully covered by the Washington Conference last November. There can be little dissent to-day from the view that it is only at the international level that effective solutions are to be found to the problems which arise from the sheer volume of scientific and technical information to-day. Even when all due weight is given to informal contacts as a means of exchanging information, the problem of communication is a fundamental aspect of the joint attack on common problems which the Duke of Edinburgh would like to see and it is also an important part of the work of the Commonwealth Agricultural Bureaux—a system, he suggested, which might be extended to other technologies. How far this is likely to be served by wider membership of research associations and fuller co-operation between them within the Commonwealth may well be a matter for some careful consideration. There are difficulties which stem from political as well as economic considerations but which might disappear in a change of political climate.

The context in which the Duke of Edinburgh discussed these problems was essentially that of promoting the speediest and most effective use of scientific knowledge for human welfare, primarily in the Commonwealth but equally throughout the world. The removal of any obstacles to human intercourse and the communication of knowledge is a first step, for without freedom of discussion and of publication there can be no effective co-operation. The people of the Commonwealth and of the world would indeed benefit by the freest possible movement of scientists, the unhampered exchange of scientific ideas and the removal so far as practicable of linguistic barriers. It is scarcely to be expected, however, that conditions for effective scientific co-operation will be created while obstacles are maintained to the circulation of ideas and of people in other fields of human endeavour, and scientific and technical co-operation should not be treated as a field apart. For the same reason, this establishment of such conditions should, however, precede the extension of any formal system of conferences, whether in relation to the attack on scientific problems or the administration and organization of research.

Science and technology depend largely on the funds placed at their service by the general body of citizens, and co-operation in these fields will only flourish when the essential conditions are sufficiently understood by Governments—and by the citizens who support them—to ensure that adequate funds are forthcoming and appropriate policies pursued. Co-operation in science and technology cannot, therefore, be divorced from consideration of educational issues, and measures directed to improve such co-operation, within or outside the Commonwealth, must include policies designed to raise the standard of general education accordingly. That is only in part, however, a matter of formal education. Much responsibility must rest on professional bodies, and on such bodies as the Parliamentary and Scientific Committee. Any attempt to improve the formal or informal framework of co-operation must be accompanied by a determined effort to enlighten public opinion, both as to what is required and as to the numerous ancillary measures which will make all the difference between the success of such aims and waste of public resources, frustration and even defeat of a calculated policy by sheer ignorance or neglect.

TRENDS IN GERONTOLOGY

A Classified Bibliography of Gerontology and Geriatrics

Supplement One, 1949–1955. By Nathan W. Shock. Pp. xxviii+525. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 120*s*. net.

Experimentelle Alternsforschung

Symposium der Europäischen Abteilung des Biologischen und Medizinischen Forschungskomitees der Internationalen Gerontologischen Gesellschaft, Basel, 4–7 April, 1956. Herausgegeben von F. Verzár. (*Experientia* Supplementum 4.) Pp. 290. (Basel und Stuttgart: Birkhäuser Verlag, 1956.) 34 Swiss francs; 34 D.M.

Ciba Foundation Colloquia on Ageing

Vol. 4: Water and Electrolyte Metabolism in Relation to Age and Sex. Edited by G. E. W. Wolstenholme and Maeve O'Connor. Pp. xii+327. (London: J. and A. Churchill, Ltd., 1958.) 45*s*. net.

Trends in Gerontology

By Nathan W. Shock. Second edition. Pp. viii+214. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 36*s*. net.

THE varied size and contents of this mixed collection of books make it difficult to review them in a connected fashion, but in their different ways the four books provide a general idea of what gerontologists have done, what they are doing, and what they hope to do.

There is not much to say about the Bibliography except to commend its completeness and accuracy (so far as I have been able to check) and to recommend it as a source book to anyone who, whether he calls himself a gerontologist or not, wants to know what work has been done both in the scientific approach to the study of aging and in the medical and sociological care of the elderly.

The next two volumes provide the material presented at symposia held in Basle and at the Ciba Foundation. On the former occasion most of the well-known names in the field were gathered together, and their papers, on the whole, are summaries of their already recognized and accepted contributions to the subject, and of their usual lines of approach to the many-sided topic of the symposium.

Among the 40 contributions (most of them in English or German, but some in French) there are descriptions of the age changes in various metabolic and organ systems to be found in a range of species, discussions of the psychological problems associated with aging, and several more directly geriatric contributions. Perhaps the most unfashionable topic to be discussed was the possibility that auto-intoxication plays an important part in aging. It was refreshing, here, to find a contribution from someone (R. B. Fisher) not usually associated with gerontology, suggesting that the intake of amino-acids in the diet is often too high and that such dietary errors could be disadvantageous to longevity, as well as the paper on more orthodox lines by Korenchevsky.

The subject-matter of the Ciba symposium, the fourth in the series, was confined to water and electrolyte metabolism. On this occasion the contributions by professional gerontologists were fewer, and the immediate relevance of some of the very excellent papers to gerontology rather more tenuous. One finds in the contents of the symposium more an attempt to exemplify the proposition that the age of an organism is an important biological variable which workers in any field must constantly bear in mind. By contrast, the topics discussed at the Basle symposium were more orthodoxly and recognizably gerontological. The Ciba volume gives the full transcript of the discussions which one has come to expect and to profit by. One gets a much clearer impression of a vital and interested meeting when one compares it with the much more scrappy transcript of the discussion in Basle.

The last of the quartet is a second edition of the book first published in 1951. The changes and the extent of development in the subject in the past eight years are very evident when one compares the virtually new chapters which Dr. Shock has had to write with the old ones. Dr. Shock confines his attention mainly to American experience and begins with a detailed statement of the economic and sociological facts—of age distribution of the population, employment, income, health services—which make a better understanding of aging processes such a compelling need. Subsequent chapters provide short abstracts of the sorts of work in the field which are going on all over the world. The scope of these chapters has extended very considerably since the first edition, but the method of stringing together short abstracts of individual programmes of work leaves one with a sense of piecemeal approach to the problem rather than a concerted attack.

There is so much change and new work in Dr. Shock's book so far that it is all the more surprising to find that his last chapter on plans for the future, where he outlines his ideas of how research in gerontology should be fostered, is unchanged. Dr. Shock proposes the setting up of a large-scale research institute, and details the way the proposal should be organized. His proposals do not really convince that this is the best way to foster the subject. The papers, at the Ciba symposium especially, reveal how frequently the parameter of age comes into all sorts of investigation and suggest that the advancement of gerontology as a reputable scientific subject now depends more on the interest that can be aroused among workers in all fields of biological study than on the provision of specialist institutes.

P. L. KROHN

AN INTRODUCTION TO ELECTRONIC THEORY

Electronic Theories of Organic Chemistry

An Introductory Treatment. By John William Baker. Pp. viii+224. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 30*s*. net.

THIS book, which is described as an introductory treatment to electronic theories of organic chemistry, is a welcome addition to the growing number of text-books now available in this field. The subject has become a well-established and indeed integral part of the teaching of organic chemistry, and it is opportune that a simple account should be available by an author who has made important contributions to it. The nomenclature and conventions follow those of the British school and more particularly of Sir Christopher Ingold and his collaborators, and the examples cited as well as the argument are drawn almost entirely from their work. This book itself follows closely the arrangement of the larger work by Ingold, including some diagrams and tabulated matter from the latter's book.

The material included comprises all the basic considerations of reaction theory, the classification of reagents as nucleophilic or electrophilic, the molecularity of reactions and the nature of various classes of rearrangements. In addition, some of the physical evidence for the existence of electron displacements, as well as a qualitative description of the quantum theory of valency, is included. Each topic is carefully and concisely explained and accompanied with appropriate examples. The book is adequately indexed.

Such criticisms as I have to offer are of a minor nature. As the author points out, Fig. 1, on p. 35, is not an adequate representation of an electronic charge-cloud. It is rather unfortunate, therefore, that some other device was not adopted the better to demonstrate the charge distribution ; particuarly in an introductory text-book such as this. Secondly, the evidence for the direct linking of the carbon–sulphur bond in bisulphite addition products may now be considered well established as a result of isotopic studies, Raman and ultra-violet spectra. This might have been made clearer in the discussion of these compounds (p. 121).

The book is well produced, as may be expected of the Oxford University Press. The lettering and the diagrams are clear and well distributed. The text is, moreover, remarkably free from casual errors, the only one that I have noticed being a missing 'h' on p. 168.

This book is to be recommended as an authoritative account of its subject-matter and one which will well repay an attentive study. The demands the book makes on a previous knowledge of structural organic chemistry may be a little severe for any but the most advanced sixth-form schoolboys, but should be within the capacity of the other readers for whom it is intended.

R. I. REED

ECONOMICS OF TELECOMMUNICATION

Telecommunication Economics

By T. J. Morgan. Pp. 452. (London: Macdonald and Co. (Publishers), Ltd., 1958.) 50*s*. net.

IF the difference between 'pure' science and engineering could be expressed by a single word, that word would well be 'economics'. Yet the amount of economics which enters into the basic training of most professional engineers is still very small. Of all branches of engineering, surely telecommunication is one of which the social, economic function is most apparent (the very word 'communication' means 'sharing'), for its primary function is to widen relationships between people, extend the speed of their actions, of their trade and business. But there are very few text-books of telecommunication suitable for students which even touch upon the economic aspects, and this thoroughly readable work will be very welcome.

The author, Mr. T. J. Morgan, is a member of the planning staff of the Post Office, which well qualifies him to write this book, having extensive experience of large-scale planning, both in Britain and elsewhere. He recognizes the relative poverty of economic studies among engineers by wisely starting his book with an apology for attempting their enrichment, continuing with an elementary account of the general principles of economics, and adding a chapter on the mathematics of statistics and probability. An excellent bibliography provides a list of texts for further detailed reading in these fields.

The influence of economic principles upon the planning and operation of large-scale telecommunication systems is gently introduced to the student, by first stressing that all engineering plant has a finite life and requires regular outlay for upkeep and operation, in addition to initial capital cost, so dictating a certain minimum utility, charges, justified development and additions, etc. ; this material is well illustrated by examples and is extended to include considerations of forecasting of future needs.

More sophisticated and specialized aspects are treated in detail, including the economics of manual and of automatic exchanges, of various types of transmission, of buildings and other ancillary structures, of traffic routing and many others.

The book is well indexed and provided with extensive references, with tables of data and illustrations. It will be welcomed by professional engineers and may well serve as a text-book for college students.

COLIN CHERRY

PROGRESS IN VITAMIN AND HORMONE RESEARCH

Vitamins and Hormones

Advances in Research and Applications, Vol. 16. Edited by Prof. Robert S. Harris, Prof. G. F. Marrian and Prof. Kenneth V. Thimann. Pp. xi+437. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 11.60 dollars.

THIS book contains nine review articles, three of them dealing primarily with nutritional matters, five of them mainly concerned with hormonal affairs, and one, entitled "The Dependence of Gonadal Function upon Vitamins and other Nutritional Factors", by C. Lutwak-Mann, with both. In this article Dr. Lutwak-Mann ranges widely and engagingly, discussing not only mammals but also birds, amphibians, fishes, marine invertebrates, and insects and trematodes. An article which extends its interest from the queen substance in honey-bees to the diet of Charles Dickens's Oliver Twist cannot fail to stimulate.

The discussion of "Nutritional Effects of Parasitic Infections and Disease", by Q. M. Geiman, is another interesting treatment of a subject ripe for review. Dr. E. E. Snell opens his article on "Chemical Structure in Relation to Biological Activities of Vitamin B_6" by posing the general question of specificity of structure and function of physiologically important compounds, and referring to the fact that any alteration in the structure of pantothenic acid diminishes its vitamin activity although, so far as we now know, the functional portion of coenzyme *A* is not present in the pantothenic acid part of the molecule. He then poses the arresting question : "Is the specificity in structure merely a developmental accident, a genetic fixation upon a useful compound that happened to be present when life first arose ?" He examines in an authoritative manner such questions in relation to pyridoxamine, pyridoxal, and their chemical relations, substances in which, as he points out, a knowledge of the relationship of structure to function is more extensive than for that of any other vitamin.

The great interest at present shown in the origin of cardiovascular disease is illustrated by the review "Vitamins and Other Nutrients in Cardiovascular Disease", by W. C. Felch, L. Sinisterra, T. B. Van Itallie, and F. J. Stare, and also by that on "Hormonal Aspects of Coronary Artery Disease", by M. F. Oliver and G. S. Boyd. "The Physiology of Secretin" is ably reviewed by M. I. Grossman, while the "Chemistry and Physiology of the Thyroid-stimulating Hormone" is discussed by M. Sonenberg. In the chapter on "Glucagon", by O. K. Behrens and W. W. Bromer, the biology and the chemistry of glucagon are succinctly surveyed, and the concluding article, entitled "Synthetic Derivatives of Cortical Hormones", by J. Fried and A. Borman, includes a consideration of the synthesis and biological activities of eleven different types of artificially produced chemical relation of the naturally occurring adrenal cortical hormones.

The book includes a cumulative index for Volumes 11–15 of "Vitamins and Hormones", which is shorter and more compact than the two previous cumulative indexes, and adequate author and subject indexes for Volume 16.

This volume should be of interest to biochemists, physiologists, to medical men, and to biologists in general, as well as to those whose interest is mainly in the chemistry of substances of biological importance. Without exception, the articles are authoritative and well written.

F. G. Young

BIOCHEMICAL ANALYSIS

Methods of Biochemical Analysis

Vol. 6. Edited by Prof. David Glick. Pp. ix+358. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 8.50 dollars.

THE sixth volume of this valuable series contains ten contributions. The first two are concerned with the determination of nucleic acids; chemical means are dealt with by J. M. Webb and H. B. Levy, and microbiological assay methods by H. K. Miller. Both contributions describe a number of different methods and both sets of authors are confident that reliable results can be obtained when these methods are applied to suitable starting materials. However, there are warnings that care must be taken if either type of analysis is applied to material of a new type and it is suggested that a new material should initially be analysed by at least two independent methods.

Formaldehyde and serine estimations are described by W. R. Frisell and C. G. Mackenzie, and purine analysis by F. Bergmann and S. Dikstein, who describe the relatively new mercury salt procedures.

Serotonin and related compounds are considered by S. Udenfriend, H. Weissbach and B. B. Brodie, who include related indoles and also the preparation and assay of enzyme systems related to serotonin metabolism. They conclude with a short section on related drugs and also include an interesting account of spectrophotofluorimetric analysis.

A determination which is now becoming of great clinical importance is transaminase, which is described by A. J. Aspen and A. Meister. A variety of procedures are included, although the section is orientated more towards the classical analysis of enzymes in tissue preparations rather than the rapid simple serum methods which to-day are used by many more laboratories.

N. S. Radin contributes a section on glycolipide determination which has valuable sections on the extraction and handling of these compounds which may be unfamiliar to workers in other fields. He also describes details of the laboratory techniques which he has found advantageous, and these are applicable also to any type of work which involves the quantitative handling of small volumes of volatile organic solvents.

The determination of thiamine by animal and microbiological assay and by chemical methods, including the well-known thiochrome technique, is described by O. Mickelson and R. S. Yamamoto. A. Kolin describes his elegant techniques of electrophoresis combined with physical gradients and shows a number of examples of the separations he obtained. Finally, S. Gardell describes hexosamine determination. His contribution and the purine chapter are the only ones by non-American authors.

The production and appearance of the volume are of the standard which we associate with Interscience Publishers.

I. D. P. Wootton

SCIENCE AND TECHNOLOGY OF RUBBER

British Compounding Ingredients for Rubber

Compiled by Brian J. Wilson. Pp. xx+528. (Cambridge: W. Heffer and Sons, Ltd., 1958. Published for the Research Association of British Rubber Manufacturers.) 60*s*. net.

Rubber

Fundamentals of Its Science and Technology. By Dr. Jean le Bras. Translated by Dr. Irene E. Berck. Pp. 464. (London: Crosby Lockwood and Son, Ltd., 1957.) 65*s*. net.

Chemistry of Natural and Synthetic Rubbers

By Prof. Harry L. Fisher. Pp. vii+208. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 52*s*. net.

TWO of these three books have been written by authors connected with national research organizations. The third has been written by an author well known for his contributions to rubber chemistry.

The books of le Bras and Fisher are eminently readable and can be perused with pleasure even by those who have spent many years in the study of rubber. They are to rubber men what such a book as Lachmann's "Spirit of Organic Chemistry" was to organic chemists of the past generation.

Wilson's book, however, is essentially a reference book similar to that published in France several years ago by Jacobs. It is limited to British products; but this has not the restricting influence that one might at first expect since so many foreign producers have associated organizations within the British Commonwealth. This book has four main sections on compounding ingredients for natural and synthetic rubbers; compounding ingredients, processing and modifying agents for natural and synthetic latices; special-purpose products such as mould lubricants, anti-tack agents, etc.; and indexes of manufacturers and trade names. The book has been produced with the thoroughness and reliability which one has come to expect from the Research Association of British Rubber Manufacturers. It is a book which no rubber manufacturer can afford to be without.

"Rubber: Fundamentals of its Science and Technology", by le Bras, is a masterpiece of conciseness. It covers the whole field of rubber in less than 500 pages. The diagrams are fascinating and carefully designed and with few exceptions explain the apparatus or plant without the necessity of referring to the text. The first four chapters are particularly excellent, and reflect the author's life-study of natural rubber. From its very size and coverage it is obviously not a reference book, and the limited references at the end of each chapter must be regarded as the personal selections of the author and not necessarily the most important. It can be recommended to students of rubber technology who have a basic knowledge of chemistry and who have already read the exhaustive treatises on particular fields as a 'refresher' before taking their examinations.

"The Chemistry of Natural and Synthetic Rubbers", by Fisher, covers, as can be judged from the title, a narrower field. It can be recommended to those rubber technologists who already possess a sound knowledge of organic chemistry. Unlike the previous book by le Bras, the chapters on synthetic rubbers are more thorough than those on the natural product. The book is essentially descriptive, and where the author has dealt with the theory behind the facts it can be taken that the most modern views have been given; for example, free radical mechanism is given as the basis of the attack on rubber by oxygen. In addition to its practical use to the young student of rubber technology, it is a book which can be read with pleasure by those to whom the facts contained in it are already known.

W. J. S. NAUNTON

TO VIEW OR NOT TO VIEW?

Television and the Child

An Empirical Study of the Effect of Television on the Young. By Hilde T. Himmelweit, A. N. Oppenheim and Pamela Vince. Pp. xix + 522. (London: Oxford University Press, 1958. Published for the Nuffield Foundation.) 42*s*. net.

THE widespread interest aroused by this report is easily understood. It is the first study of its kind to be conducted among English-speaking peoples and, indeed, probably in the world. Unlike so many other pronouncements about the effects of this popular new medium on children, it is truly a scientific survey conducted on a large enough scale to make its findings weighty and authoritative. It should, for example, cause many school medical officers to hesitate before they include in their annual reports pontifical and unsubstantiated judgments about the harmful effects of television on children's eyes, posture and behaviour.

The report is of value not only for the observations it makes but also for the deductions which may be made from them. Among the more cheering conclusions is that children of healthy interests and appetites seldom become addicted to television and that there are comparatively few children who do. Nor do children view continuously from the time they get home from school until they go to bed. Most children view selectively and exercise a good deal of discrimination; working-class children do not view more continuously than those from the middle-classes. In general, television does not cause listlessness, loss of sleep, bad dreams, lack of concentration, or eye strain. Children are not made more passive or become more aggressive, or kept away from youth clubs by television.

Against this are a number of conclusions which, on balance, suggest that television, as at present administered, has more harmful than beneficial influence on children. Most viewing by children is done up to 9 p.m. and, since the introduction of the second channel, is done by switching from channel to channel to find their favourite programmes. These programmes often consist of plays or playlets which, while differing superficially, show much uniformity in the values and stereotypes which they present and have a slow but cumulative effect on the outlook of the child viewer. Since the world of television drama tends to be that of upper middle-class urban society, the occupations of people of this level are depicted as worth while, whereas manual work is presented as uninteresting. Although television plays teach that self-confidence and toughness are needed to achieve success they also show that goodness of character is not enough; that life is difficult, especially for women; that marriages are frequently unhappy, and parent-child relationships often strained. Events rarely turn out satisfactorily, and virtue seldom brings happiness in its train. Violence is an inevitable part of life, and good people often resort to it. For the adult observer a hackneyed view of life emerges, similar in many ways to that offered in the cinema or theatre; for the child television may afford a glimpse of adult life which he would otherwise gain less often and only at a later age. What television can do is indicated by the conclusion that, probably as a result of B.B.C. programmes about foreign (and especially European) countries, viewers made fewer value judgments about foreigners; where stereotypes were given, they tended to reflect those offered by television.

All in all, the values of television can make an impact if they are consistently presented in dramatic form, and if they touch on ideas or values for which the child is emotionally ready. Extrapolating from these findings, one would expect that in crime and detective series the constant display of aggression by both the criminal and the upholder of the law would also make an impact on those children sensitized to such cues.

The main recommendation made by Dr. Himmelweit and her colleagues is that the B.B.C. and I.T.A. must collaborate much more over the balance of programmes; worthwhile programmes should go out on the air at the same time. They also recommend that producers should be supplied with more information about the effects of programmes on their audiences. Here the Granada Television Company should be commended for its initiative in sponsoring a fellowship at the University of Leeds to examine the impact of programmes on audiences.

What the authors do not openly recommend is that before the Government authorizes the use of a third channel, the B.B.C. and I.T.A. should prove themselves worthy trustees. The I.T.A. particularly would need clear direction and close supervision before it could be entrusted with a task which all its previous performance suggest it is unfitted to perform.

Parents and teachers who read this report would do right to insist on substantial guarantees.

Gem Testing

By B. W. Anderson. Sixth edition, revised and reset. Pp. 324. (London: Heywood and Co., Ltd., 1958.) 42*s*. net.

A CENTURY ago the identification of gemstones was the speciality of experts in the trade who, by long experience and from lore handed on from masters to apprentices, had learned to judge their gemstones by sight and touch with little beyond a lens and perhaps a file to help them. The use of simple scientific methods for determining density and the optical characters of gemstones as a means of identification had long been advocated by a few enthusiasts but not generally adopted. It was not until the appearance on the market of synthetic rubies, sapphires and spinels that the scientific methods began to gain more general acceptance. New methods had to be devised to distinguish natural from synthetic stones and, later, to distinguish cultured pearls from natural ones. The London Chamber of Commerce set up a laboratory for testing diamonds, pearls and precious stones, the Gemmological Association of Great Britain was founded, and lecture courses on gemmological subjects were commenced. The author of this book is the head of the laboratory and for many years he has taught and examined for the Association. His book is the best on this subject, and in the sixth edition there is much that is new.

The author is a strong advocate of the use of a direct-vision spectrometer for identification of gemstones by their absorption spectra, and the chapter on this part of the subject has been largely re-arranged and illustrated.

A neat method of comparing the refractive indices of a number of gemstones is described. It depends on observing, or photographing, the shadows the stones throw when immersed in a liquid with a refractive index near their own while illuminated from above. The use of a contact photograph and ultra-violet light can be made to show at a glance the difference betweeen natural and synthetic rubies,the latter being definitely more transparent to ultra-violet light. More use is being made of the study of inclusions in gemstones, a branch of the subject extensively studied by Dr. E. Gübelin of Berne. Many of his photomicrographs of inclusions are used in this book.

These are only a few of the tests the author describes. W. CAMPBELL SMITH

Behavior and Psychological Man

Essays in Motivation and Learning. By Prof. Edward Chace Tolman. Pp. xiv+269. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1958.) 1.95 dollars; 17*s*. 6*d*.

THIS volume is a reprint of Tolman's "Collected Papers in Psychology" first published in 1951 and it includes a warm and appreciative foreword by his colleagues at the University of California. The papers have been chosen to indicate the successive stages in the development of Tolman's theoretical system.

Prof. Tolman's contributions to psychological theory and experiment are equally outstanding. This will be granted without necessarily sharing his views. He is the exponent of 'molar' behaviourism, in contrast to the 'molecular' behaviourism of the school of Clark Hull at Yale; and he has gone further than any other behaviourist in trying to embrace within his system essential features of *Gestalt*, psychoanalytic, and hormic theory in terms of operationally defined variables.

The considerable achievements of Prof. Tolman mark a characteristic phase in the development of psychology. His experimental work, however, must be disentangled from its theoretical framework. The latter rests on a positivistic philosophy the validity of which is not self-evident. Indeed, it would seem that the behaviouristic positivism pursued by Prof. Tolman in the interests of scientific rigour has, in fact, been detrimental to the psychological 'all-inclusiveness' to which his system aspires. JOHN COHEN

The Excitable Cortex in Conscious Man

By Dr. Wilder Penfield. (The Sherrington Lectures, 5.) Pp. ix + 43. (Liverpool: Liverpool University Press, 1958.) 10*s*. 6*d*. net.

THIS book presents a summarized version of the data which the author has accumulated from the responses to electrical stimulation of the cerebral cortex during operations on the human brain. It also elaborates the author's hypothesis of a 'centrencephalic system' within the brain, concerned with higher integrative processes. The sensations which patients describe when the visual, auditory or somatic sensory area of the cortex is stimulated, are discussed, together with the movements elicited by stimulation of the motor cortex. The effects of stimulation of the temporal lobe, particularly psychic responses, are dealt with in more detail and in relation to temporal lobe epilepsy. The author points out that the clinician must contribute to science "as best he can from very different material and as chance presents it". Certainly he appears to have made good use of the material available to him in his long experience as a neurosurgeon.

While the book contains little that is not available in the other writings of this author, it presents this material in a very acceptable form, well illustrated, and with clinical examples. It should be easily understood by those with little knowledge of neurology and to the student it provides a useful introduction to this field of research. P. B. BRADLEY

Information Service in Libraries

By D. J. Foskett. (Crosby Lockwood's New Librarianship Series.) Pp. vii+142. (London: Crosby, Lockwood and Son, Ltd., 1958.) 13*s*. 6*d*. net.

IN this little volume Mr. D. J. Foskett presents a concise but thoroughly competent survey of the development of information service in libraries and the various aspects of that work to-day, as well as the qualifications demanded of those who carry such responsibilities. To anyone contemplating such a career he offers much sound advice, while to those already occupying posts as information officers or as librarians he indicates problems where further thought and much closer co-operation are needed. Mr. Foskett does not hesitate to express his own opinions or preferences; but his point of view is always reasonably argued and it is incidentally rather than by direct attack that he shows how trivial is the attempt to draw a division to-day between the librarian and the information officer or between the handling of scientific and technical literature or any other form of literature. The bibliographies appended to his several chapters are adequate and balanced, and this book should both provoke useful debate and help the beginner to master his profession. R. BRIGHTMAN

NON-FLAGELLAR APPENDAGES OF BACTERIA

By Dr. CHARLES C. BRINTON, jun.

Laboratoire de Biophysique, Institut de Physique, Université de Genève,
and Department of Biophysics, University of Pittsburgh

BACTERIAL pili (Latin, hair or fur) are recently discovered filiform appendages found growing from the surface of many different species of bacteria. They are thinner, straighter, and more numerous than flagella (Fig. 1) and have a uniform diameter of about 80–100 A. They are only visible in the electron microscope, and have been independently observed by several workers[1,2]. The first detailed study of pili, by my colleagues and me[3], demonstrated the existence of two distinct phases within one bacterial strain, piliated and non-piliated, distinguishable from each other either in the electron microscope or by microscope electrophoresis, the electrophoretic mobility of the piliate cells being about half that of the non-piliate cells. Each phase could spontaneously change into the other at a rate of the order of 10^{-3} per bacterium per division. The pili were fragile and could be removed almost entirely by mechanical agitation in a high-speed mixer (Fig. 2). The electrophoretic mobility of these depiliated bacteria was nearly the same as that of the non-piliate form; but, in a few minutes, the mobility decreased to its original value, indicating re-growth of the pili. Cell-free filtrates of piliated bacteria could apparently inactivate the even-numbered *T*-phages. Maccacaro and Angelotti[4] investigated the distribution of piliation in eleven strains of *Escherichia coli K*-12 having various combinations of genetic markers for fermentation, nutritional requirements, antibiotic resistance and bacteriophage resistance, and confirmed the existence of distinct piliate and non-piliate forms but observed no definite correlation between piliation and any of the above genetic markers.

Duguid *et al.*[5,6] surveyed a large number of bacterial strains of different genus and species for the presence of pili, and found piliation in most strains of *E. coli*, *Shigella flexneri*, *Salmonella*, *Klebsiella*, *Proteus*, *Chromobacterium prodigiosum* and *Bacterium cloaceae*. The ability to adhere to and agglutinate red blood cells was most often associated with piliation, although a few piliate strains could not agglutinate and some non-piliate strains could. These authors also confirmed the phenomenon of spontaneous reversible change between the piliate and non-piliate phases. Gillies and Duguid[7] prepared high-titre antisera against piliate strains of *Shigella flexneri* which agglutinated them and also inhibited their hæmagglutinating activity. A cross-reaction with *E. coli* was demonstrated.

Pili have been called by several different names: 'fine threads'[1], 'bristles'[8], 'fimbriæ'[5–7], and 'filaments'[2–4,9]. It is felt that the word 'pilus' is the most descriptive term, since the pili usually cover most of the bacterial surface and are continually growing out in a manner quite analogous to hair or fur.

The present article is a summary of results of investigations on the genetics, biological activity, chemistry, and electrophoresis of pili carried out during the past three years at the Biophysics Departments of the University of Geneva and the University of Pittsburgh. This work will be published elsewhere in detail.

Genetics

Quantitative genetic analysis has been greatly facilitated by the discovery that the piliated phase of *E. coli* forms smaller and smoother colonies (Fig. 5) on solid media than the non-piliated form[10]. This distinctive colonial difference has been found to exist for all piliate strains of *E. coli* examined so far. Conversely, that a colony difference means a difference in piliation, does not hold; rough and smooth colonial forms of the same strain can exist in the absence of any piliation. A relative count of piliate and non-piliate forms was made on the same suspension of *E. coli B* strain *L*(*E*) by three independent methods: (*a*) electron microscope count of morpho-

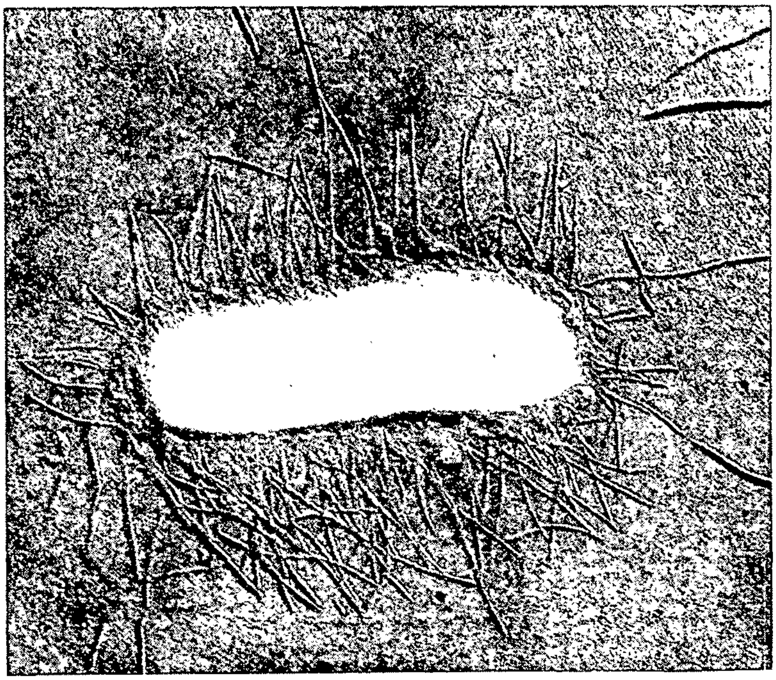

Fig. 1. A piliated bacterium growing on a collodion membrane overlying a nutrient agar base. Spheroidal surface material can be seen on or near the organism. Strain *E. coli B*-*L*(*E*)P^{+}

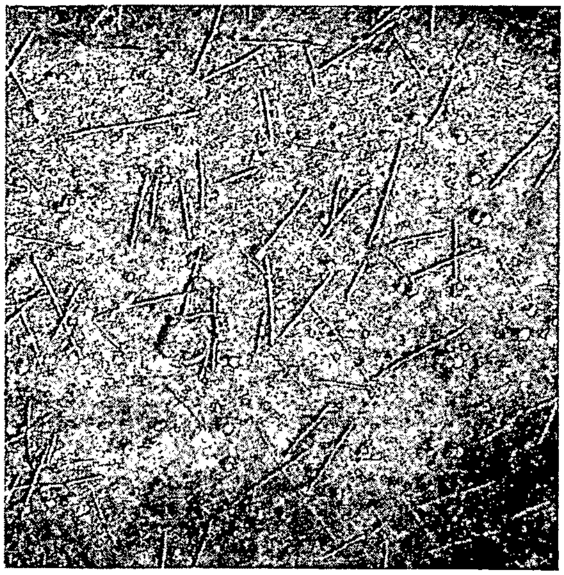

Fig. 2. Electronmicrograph of crude preparation of pili obtained by shaking a culture of piliated bacteria and centrifuging out the deflamented organisms

logically piliate and non-piliate forms; (*b*) electrophoretic count of 'fast' and 'slow' organisms; and (*c*) colony count of smooth and rough colonies. The averages of nine relative counts by each of the three methods were the same within an experimental error of 3 per cent. All three methods clearly distinguish between two distinct forms: completely piliate ($P+$) or completely non-piliate (P^-); if intermediate forms exist, they are rare. 14 of 19 strains of *E. coli B* and *E. coli K*-12 were found to possess the potentiality for piliation. It is quite possible that the remaining 5 strains also had this capacity, but that the P^- phase was dominant under the cultural conditions of the survey (aerated tryptone at 37°).

In order to obtain more basic, quantitative information, a single strain, *E. coli B*, *L*(*E*), was chosen for investigation because of its rich piliation (Fig. 1) and clean-cut difference between $P+$ and P^- colonies (Fig. 5). A 99·9 per cent pure $P+$ culture was prepared by inoculating a single smooth colony into aerated tryptone and growing to 10^8 organisms/ml. at 37°. From this culture, parallel tubes at 37° were inoculated with an average of 0·3 organisms per tube, which guaranteed that most of the tubes which eventually showed growth started from one or two bacteria. The fraction of non-piliate organisms, *f*, was followed as a function of time in each tube showing growth, and typical results are plotted in Fig. 6. The bacterial concentration was maintained in the neighbourhood of 10^8 organisms/ml. by dilution.

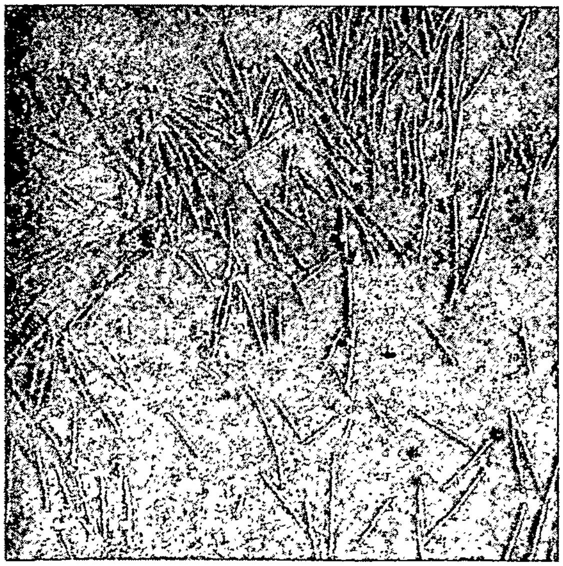

Fig. 3. Sample of pili taken from faster electrophoretic component

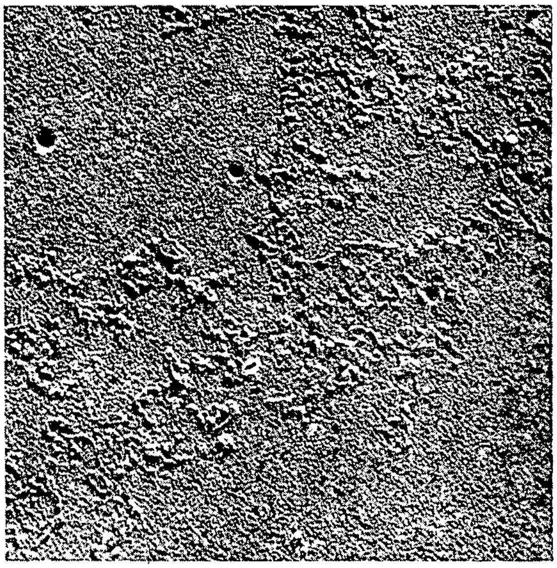

Fig. 4. Sample of spheroidal surface material taken from slower electrophoretic component

The shapes of the curves in Fig. 6 can be explained by assuming that the rate of the $P+ \rightarrow P^-$ 'mutation' (in the formal sense of a sudden, inheritable change having a constant probability per organism per division) is about 4×10^{-4} per bacterium per generation, the reverse mutation-rate is negligible and the $P+$ phase has a generation time about 10 per cent greater than the P^- phase. As soon as enough P^- bacteria have arisen by mutation they rapidly take over the culture because of their higher growth-rate. The theoretical statistical distribution for the average number of mutants per culture in a series of parallel cultures has been derived by Armitage[11]. For the case of no back mutation and unequal growth-rates of parent and mutant, equations 70 and 71 of Armitage may be used. The theoretical means of values of *f*, calculated assuming a mutation-rate of $\alpha = 4 \cdot 3 \times 10^{-4}$ and generation times of $t_p + = 32 \cdot 2$ min. and $t_p - = 29 \cdot 0$ min., is plotted as a function of number of generations in Fig. 6. These numerical values were assumed in order to fit the experimental data; however, the validity of this model is borne out by independent measurements of the mutation-rate and the growth-rates.

The $P+ \rightarrow P^-$ mutation-rate was determined by the 'zero-point' method, which is independent of any selection due to differences in growth-rate. The entire contents of parallel $P+$ clones were plated out when the clones contained an average of about 1,000 cells and the fraction of clones containing no P^- colonies was determined. The mutation-rate as

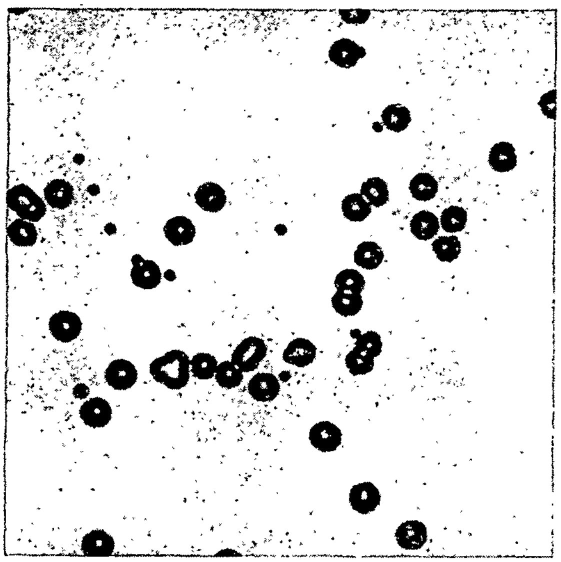

Fig. 5. Colonies of *E. coli B-L(E)* growing on nutrient agar. The larger, rougher colonies are the non-piliated form (P^-) and the smaller, smoother colonies are the piliated form (P^+)

given by the formula $\alpha = -\ln P/N$, where α is probability of mutation per bacterium per division[12], P is fraction of clones having no mutants, N is average total number of cells in the clones, was $3{\cdot}8 \times 10^{-4}$, which is in good agreement with the rate estimated from Fig. 6. The variance of the distribution of numbers of $P-$ mutants in parallel clones is approximately equal to the theoretical variance calculated from equations 70–74 of Armitage[11], which were derived from the hypothesis of spontaneous mutation.

The mutation-rates at four different temperatures were determined by the zero-point method and are plotted in Fig. 7. For a 10-deg. rise in temperature, the mutation-rate decreases by a factor of 10.

The generation times of the two pure phases in tryptone at 37° as determined by colony counts, and optical density measurements were found to be $P+$: 30·5 min. and $P-$: 29·0 min. When pure $P+$ and $P-$ cultures were mixed and grown at 37°, the fraction of P^- organisms increased with the slope expected from the differential growth-rate. The relative growth-rate of the $P+$ and $P-$ phases was also found to be dependent on temperature. In Fig. 8 the ratio of the $P+$ generation time to the $P-$ generation time is seen to decrease with temperature, passing through 1·0 at about 41°. When a mixture of $P+$ and $P-$ cultures was grown at 42°, the fraction of $P-$ cells in the culture decreased as expected.

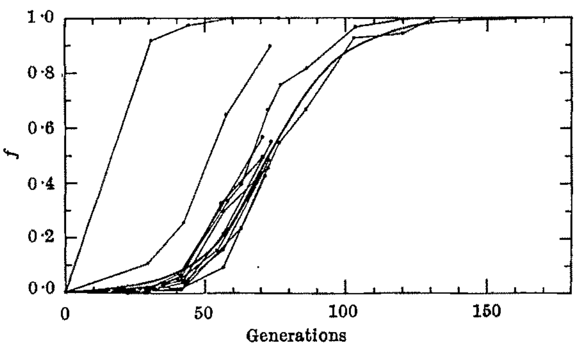

Fig. 6. The $P^+ \rightarrow P^-$ mutation in aerated tryptone at 37°. Points for individual cultures are connected by thin straight lines; the heavy smooth curve is the theoretical one calculated from Armitage's equations (ref. 11)

The dependence of mutation-rate and relative growth-rate on temperature shown in Figs. 7 and 8 formed the basis of methods for growing and maintaining pure $P+$ and $P-$ cultures. Pure $P+$ cultures were obtained by plating out a mixed culture and incubating at $> 41°$, picking a single smooth colony, and inoculating into broth with incubation at $> 41°$. Pure $P-$ cultures were obtained by inoculating a single rough colony and incubating at any temperature, since the $P- \rightarrow P+$ mutation has not been observed in this strain.

Strain $L(E)$ is somewhat anomalous in that the $P+ \rightarrow P-$ mutation is not readily reversible as in some other strains. Temperature effects on the stability of $P+$ and $P-$ forms have been observed in other strains. All genetic experiments were carried out in aerated tryptone; mutation- and growth-rates may be different in other media.

Electrophoresis

The electrophoretic mobility of piliate and non-piliate bacteria and of pili free in solution has been

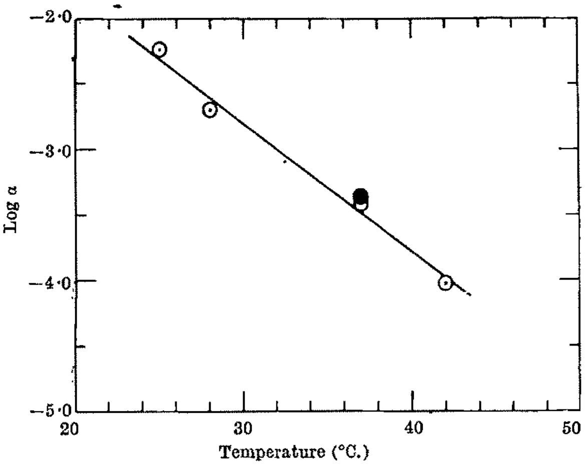

Fig. 7. The $P^+ \rightarrow P^-$ mutation-rate, α, as a function of incubation temperature. Open circles, experimental points; solid circle, value of α used for plotting the theoretical curve of Fig. 6

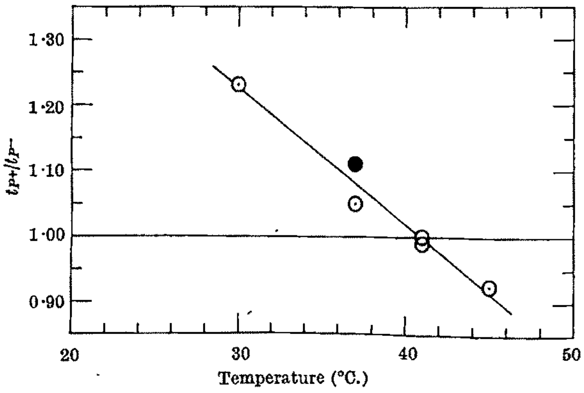

Fig. 8. Relative generation time, t_{P^+}/t_{P^-}, of P^+ and P^- bacteria as a function of temperature. Generation times were determined separately on pure or almost pure P^+ or P^- cultures both by optical density measurements and colony counts. The experimental points are the open circles; the solid circle is the point calculated from the values of t_{P^+} and t_{P^-} used to plot the theoretical curve of Fig. 6

determined as a function of pH and ionic strength. Over a wide range of pH (6–11) and ionic strength (0·0003–0·1000) the mobility of free pili is the same as the mobility of piliated bacteria, demonstrating that the mobility of piliated cells is determined solely by the pili. This means that calculations of the average surface charge density cannot be made using the usual equation employed for bacteria and cells valid only for flat, smooth surfaces ($\varkappa a > 100$)[13]. The radius of curvature used in the charge density equations must be at least as small as the 40–50 A. radius of the pili.

The forms of the salt concentration–mobility curves for the $P+$ cells and the P^- cells in acetate buffer are almost identical to the curves obtained by Moyer[13] for smooth and rough strains of *E. coli* and by Stearns and Roepke[14] for smooth and rough strains of *Brucellus abortus*. In all three cases, the smooth-colony form had the lower mobility.

When a culture of $P+$ bacteria is mechanically agitated in a high-speed mixer for 2 min. and the cells centrifuged out, a suspension of free pili and 'spheroidal surface material' is left behind (Fig. 2). The free boundary electrophoresis pattern of this suspension shows two distinct, homogeneous peaks. When samples of each component were examined in the electron microscope, the leading boundary sample was almost pure pili (Fig. 3) and the trailing boundary sample was pure spheroidal surface material (Fig. 4). The spheroidal surface material in Fig. 4 appears somewhat degraded compared with that shown in Fig. 2; this is possibly due to the high pH ($pH = 10·3$) used in this particular electrophoresis run. Free boundary electrophoresis provides a useful method for the separation of these two components, which is difficult by centrifugation or isoelectric precipitation.

Biological Activity

The cell-free culture fluid of shaken $P+$ cultures of *E. coli B–L(E)* has at least three biological activities: agglutination of red blood cells, inactivation of certain bacterial viruses, and antibiotic activity against another strain of bacteria (colicine *E* activity)[15]. The identification of these three activities with the two morphological components has been investigated.

Hæmagglutinating activity was measured by the ability to cause visible aggregation in small glass tubes of 0·2 per cent chicken red blood cells. A cell-free culture fluid prepared from piliate bacteria and concentrated about 1,000 times by isoelectric precipitation gave a hæmagglutination titre of 10,240; unconcentrated fluid gave a titre of 8. Pili from broth-grown $P+$ bacteria had about 30 times the hæmagglutinating activity of pili from bacteria grown in synthetic medium (*M*9). An agglutination test of electrophoretically separated pili and spheroidal surface material showed that all the activity was associated with the purified pili and none with the spheroidal surface matter. This is the first demonstration of hæmagglutinating activity associated with free pili; 0·5 μgm./ml. of this preparation was sufficient to give a positive test. Other convincing evidence that the pili themselves are the organs of hæmagglutination rather than some other material produced by piliate organisms was obtained. Low concentrations (1 bacterium per blood cell) of pure $P+$ cultures will hæmagglutinate while very high concentrations (1,000 bacteria per blood cell) of pure $P-$ cultures will not[10]. When the pili are removed from solution by centrifugation, isoelectric precipitation, or ammonium sulphate precipitation, the hæmagglutinating activity is also removed.

Anti-viral activity[3,16] was measured by mixing cell-free culture fluid with bacteriophage *T*2 and assaying for phage as a function of time by the plaque count method. Unconcentrated cell-free culture fluids of both $P+$ and $P-$ cultures showed the same activity (6 per cent survival after 60 min. at 37° of an initial phage concentration of 10^8/ml.), demonstrating independence of anti-viral activity and pili. The activity of electrophoretically separated samples showed most of the anti-viral activity to reside in the spheroidal surface material fraction and very little in the pili fraction. Electron microscopy of a mixture of phage *T*2 and cell-free $P+$ culture fluid shows the phage particles adsorbed to the spheroidal surface material and no apparent association of pili with the phage. The spheroidal surface material is only active against the even-numbered *T*-phages.

Colicine activity was measured by adding a strain of *E. coli* sensitive to killing by colicine *E* (strain 'Rowley') to various dilutions of cell-free culture filtrate and incubating for 30 min. at 37°, then plating on solid medium. The last dilution showing at least 50 per cent inactivation of the indicator strain was taken as the colicine titre and was about 10^4 for both $P+$ and $P-$ culture fluids. Removal of pili and spheroidal surface material by centrifugation left the colicine activity in the supernatant fluid.

Thus, the above experiments are consistent with the view that pili are the organs of hæmagglutination, spheroidal surface material is the antiviral agent, and colicine *E* is associated with neither.

A possible correlation of piliation with fertility was investigated, but both $F+$ and $F-$ bacteria of one strain (*E. coli K*-12, *W*677) were piliated while neither $F+$ nor $F-$ bacteria of another strain (*E. coli K*-12, 58–161) were piliated. A strain of *E. coli* showing high frequency of recombination (*Hfr* of Hayes[17]) was non-piliated.

No non-flagellated strain of *E. coli* was ever motile although many were piliated. Piliation seems to occur quite independently of flagellation and motility. The pili of motile strains are usually much shorter than in non-motile strains, presumably due to fracture of the pili by bacterial motion.

Chemistry

Preliminary chemical analysis of partially purified pili suspensions indicate that pili contain at least some protein. Kjeldahl analysis showed 4·6 per cent nitrogen; xanthoproteic and biuret tests were strongly positive; the ninhydrin test was slightly positive before and strongly positive after prolonged acid hydrolysis. The ultra-violet absorption spectrum has a maximum at 279 mμ and a minimum at 252 mμ, which is typical for many proteins. Pili are precipitable by ammonium sulphate or acid.

Pili seem to be quite stable. Morphologically, the pili of *E. coli B L(E)P* are unaffected by long standing at pH 3–12 at room temperature or by heating to 95° for 2 min. at pH 7 or 10. This is in agreement with the observations of Weibull[9] for *Proteus* pili and of Duguid *et al.*[5] for pili of *Shigella flexneri*. Weibull found that pili of *Proteus vulgaris* were resistant to 1 *N* hydrochloric acid or sodium hydroxide, trypsin, pepsin, ribonuclease, or deoxyribonuclease as judged by appearance in the microscope. He also found that flagella from the same strain disintegrated at a low pH while the pili did not. In the light of the resistance of pili to various protein denaturants it seems unlikely that they are pure proteins.

Serology

A pure rabbit antiserum against *E. coli B L*(*E*) pili was prepared by several courses of injection of an electrophoretically separated pili suspension. This antiserum agglutinated a pure $P+$ culture after 1 hr. at room temperature at a dilution of 2,560 but did not agglutinate a pure $P-$ culture even at a dilution of 2. This serum has not yet been tested for cross reactions.

The growth of $P+$ and $P-$ colonies on agar plates is completely unaffected by the presence of anti-pili serum at an agglutination titre of 500.

I wish to thank Dr. Edouard Kellenberger and Dr. Max A. Lauffer for constant advice and encouragement, and Mrs. Alice McGough for her competent technical assistance. This research has been supported in Geneva by the Fond Nationale Suisse.

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THE REFINING OF URANIUM IN THE UNITED KINGDOM

By D. P. HAMILTON

Chemist Training Officer, Springfields Works, U.K. Atomic Energy Authority

IN the Atomic Energy Act of 1946, the Prime Minister (then Mr. C. Attlee) announced the setting up of an organization within the Ministry of Supply to produce fissile material. Ten years later, as a result of the efforts of everyone in this completely new industry, which embraces every branch of science and engineering, Calder Hall, the world's first nuclear power station, began generating electricity for the national grid. The growth of the organization during the years between had been so rapid that in 1954, a separate body, the United Kingdom Atomic Energy Authority, was formed, a step made necessary because flexibility and speed of decision were required, and these would be obtained more easily from an organization set up on industrial rather than Civil Service lines. In addition, the creation of the Authority facilitated co-operation with all branches of industry, and as a result, the functions of the Authority—"to cover the whole field of Atomic Energy and radioactive substances"—could be rapidly and most economically developed.

The success of the British atomic energy project depends entirely on the production of uranium in a highly refined state, and the Springfields Works of the Authority is thus in a position of prime importance in supplying the country's requirements of natural uranium fuel elements for reactors such as those used at Calder Hall, Chapel Cross, and those shortly to be commissioned by the electricity generating boards, besides the fuel required for experimental nuclear reactors. During the past ten years, Springfields Works has produced almost one million fuel elements of varying kinds, and now, to meet the demands of the national nuclear power station programme—which envisages an installed generating capacity of 5–6 thousand megawatts by 1966 from nuclear power stations, a new Springfields Works has been built to supply the fuel elements required by those stations. Those new Works were open recently to the Press and, as a result, it is now possible to describe briefly the work which goes on there.

Uranium ore arrives at the factory in sealed drums from various Commonwealth countries, in the form of uranium concentrates which have been prepared from low-grade uranium-bearing ores from Canada, South Africa and Australia, by leaching with sulphuric acid in the presence of an oxidizing agent (such as manganese dioxide or sodium chlorate) at the mining site, producing a material which contains 70–90 per cent uranium oxide.

The ore concentrate on arrival at Springfields is tested for its uranium content before being tipped into large stainless steel dissolvers, where it undergoes a 'stewing process' with nitric acid to dissolve out the uranium (and other metallic elements) as uranyl nitrate. This part of the process may be represented by the reaction:

$$\underset{\substack{\text{uranium}\\ \textit{ex.}\text{ ore}}}{U} + \underset{\substack{\text{nitric}\\ \text{acid}}}{4HNO_3} \rightarrow \underset{\substack{\text{uranyl}\\ \text{nitrate}}}{UO_2(NO_3)_2} + \underset{\substack{\text{nitric}\\ \text{oxide}}}{2NO} + \underset{\text{steam}}{2H_2O}$$

The uranyl nitrate along with undissolved material is fed to the trough of a rotary filter. As the solution of uranyl nitrate is sucked through the specially prepared filtering surface of the horizontally rotating drum and discharged from the centre of the drum, the insoluble impurities collect on the surface and are removed by an advancing knife-edge.

The filtered uranyl nitrate solution is freed from other dissolved matter by a solvent extraction process. Uranium has the property of selective solution in certain oxygenated organic solvents; with tributyl phosphate the uranyl nitrate forms a complex, $UO_2(NO_3)_2.2(C_4H_9)_3PO_4$, which is soluble in odourless kerosene, the latter being used in admixture with the tributyl phosphate as a diluent. The kerosene–uranyl nitrate–tributyl phosphate complex solution is mixed with a dilute nitric acid solution to remove the impurities and the mixed phases of different specific gravities are then allowed to settle out into two layers. This 'mixing–settling' process continues in a specially designed counter-current extractor so that removal of the uranyl nitrate from the aqueous phase and its transfer to the solvent phase may be made almost complete. From this extractor the solvent mixture emerges loaded with uranyl nitrate, and then enters a similar type of extractor to meet a backwash of demineralized water. The result is a flow of pure uranyl nitrate in aqueous solution.

The purified uranium is precipitated from the aqueous solution as ammonium diuranate by the addition of ammonium hydroxide :

$$\underset{\text{uranyl nitrate}}{2UO_2(NO_3)_2} + \underset{\text{ammonium hydroxide}}{6NH_4OH} \rightarrow \underset{\text{ammonium diuranate}}{(NH_4)_2U_2O_7} + \underset{\text{ammonium nitrate}}{4NH_4NO_3} + \underset{\text{water}}{3H_2O}$$

The diuranate is then passed in batches through the 'dryway process', where it is converted to uranium tetrafluoride in a reacting vessel placed in an electrically heated furnace. The atmosphere inside the vessel is changed at each of three stages of the process. In the first stage the diuranate is calcined to drive off ammonia and steam, thus converting it to uranium trioxide :

$$\underset{\text{ammonium diuranate}}{(NH_4)_2U_2O_7} \rightarrow \underset{\text{uranium trioxide}}{2UO_3} + \underset{\text{ammonia}}{2NH_3} + \underset{\text{steam}}{H_2O}$$

During the second stage, hydrogen is admitted to the reacting vessel to reduce the trioxide to the dioxide :

$$UO_3 + H_2 \rightarrow \underset{\text{uranium dioxide}}{UO_2} + H_2O$$

The third, and final, stage converts the dioxide to uranium tetrafluoride by means of hydrogen fluoride gas :

$$UO_2 + \underset{\text{hydrogen fluoride}}{4HF} \rightarrow \underset{\text{uranium tetrafluoride}}{UF_4} + 2H_2O$$

This conversion process from uranyl nitrate to uranium tetrafluoride is also to be modernized and made continuous instead of batchwise by the introduction of fluidized bed techniques, and the plant for this is at present under construction. When it is complete, the uranyl nitrate solution will be concentrated and then sprayed into the first of three linked reactors. The water will be removed and the nitrate decomposed to form uranium trioxide powder, which will be fluidized by an upward current of air and transferred to the second reactor. Here the fluidizing gas will be hydrogen, which will reduce the uranium trioxide to dioxide, and finally in the third reactor a stream of anhydrous hydrofluoric acid will complete the conversion to uranium tetrafluoride.

It is from this tetrafluoride that the thermal metallic reduction occurs to give pure uranium metal. The choice of a reducing metal is limited to calcium or magnesium, and at Springfields magnesium is used because it can be obtained in very pure form and also at a lower price than calcium, although there is the disadvantage that with magnesium the reaction must be carried out in a sealed reacting vessel, externally heated.

The tetrafluoride is intimately mixed with magnesium turnings and fed into a pelleting press which ejects pellets of the mixture for delivery to the reaction vessel. This is a long steel cylinder lined with graphite sleeves inside which the pellets are built up. The loaded reaction vessel is then placed in an electric furnace, where the reduction reaction occurs :

$$UF_4 + 2\,Mg \rightarrow U + \underset{\substack{\text{magnesium fluoride}\\ \text{(slag)}}}{2\,MgF_2}$$

Although a temperature of several hundred degrees is required to initiate the reaction, it is strongly exothermic and produces a high enough temperature in the crucible for the uranium to be formed in a molten state. Its high density causes it to collect as a solid billet in the base of the vessel, with a slag of magnesium fluoride above it.

On cooling, the vessel is dismantled and the slag and uranium billet removed. The latter is cleaned of adhering slag, sampled for chemical purity, and then passes from the purely chemical process to the metallurgical side of the process—the conversion of the pure uranium metal into a fuel element.

The uranium billet is melted in a graphite crucible in an induction vacuum furnace from which the molten metal drops into a number of vertically arranged cylindrical moulds via a distributor plate. After cooling, the mould assembly is dismantled and the rods removed, each casting being kept separate. In order to bring the rods into a satisfactory metallurgical condition, that is, to minimize distortion or 'creep' during irradiation in the pile, they now undergo two heat-treatment processes—quenching and annealing, the object of which is first to reduce the grain size of the uranium crystals and give them a random orientation, and then to release any stresses set up in the metal as a result of this operation. On completion of the heat treatment processes, the metal rods are machined on conventional types of lathes, checked for dimensional accuracy and rigorously inspected before being passed on for assembly into fuel elements.

It is necessary to seal the uranium rod in a suitable container to prevent escape of gaseous fission products into the pile coolant, to prevent possible reaction of the coolant with the uranium rod, and to restrict the deformation of the rod resulting from irradiation and repeated heating and cooling.

The cans used at Springfields consist of helically finned open-end tubes made from magnesium alloy known as 'Magnox'. These cans are made scrupulously clean by immersion in trichlorethylene, after which they undergo a comprehensive examination for possible errors in fabrication. Following this, one end is sealed by an argon-arc welding technique and the uranium rod is inserted into the can. The second end cap is then welded into position and the completed fuel element undergoes pressurizing in an autoclave to squeeze the can on to the rod to ensure good heat transfer from rod to can. The fuel element is then examined by X-rays in order to detect any flaws which may have arisen during the canning process, cleaned once more, a brace assembly fitted, end pieces attached, and finally inspected before dispatch for use in the nuclear reactor.

In the short space of ten years, Springfields Works has built up an unrivalled team of personnel skilled in the techniques of refining uranium and fabricating fuel elements, and they are confident that the United Kingdom nuclear power programme, and the performance of British reactors abroad, rests on the firm foundation of a reliable fuel.

OBITUARIES

Prof. F. J. Cole, F.R.S.

FRANCIS JOSEPH COLE was born at Clapham in 1872, and by his death on January 27, a week before his eighty-seventh birthday, British zoology lost an outstanding scholar. He was educated at Sir Walter St. Johns School, Battersea, where the only science subject he studied was physics. Reading Darwin's "Vegetable Moulds and Earthworms" in his teens inspired him to keep and study these creatures, and his first three publications were notes on his observations. He also started buying books, and E. B. Wilson's classical memoir on the development of the earthworm made a deep impression on him by the accuracy of description, careful illustration and extensive bibliography.

In 1892 he was assistant to Prof. J. Cossar Ewart in Edinburgh, and his experience while there played a significant part in shaping his subsequent career. He collaborated with Ewart in a paper on the cranial nerves of elasmobranchs, the forerunner of a series of publications on the cranial nerves of fishes which firmly established his reputation as an able comparative anatomist and were recognized by the award of the Rolleston Prize by Oxford in 1902. These researches contributed to the establishment of the now generally accepted 'component theory of the nervous system' and they brought to his notice the works of the old masters of anatomy.

In 1895 Cole went to Liverpool as lecturer under Prof. W. Herdman, continued his line of research, and with James Johnstone produced "*Pleuronectes*", which still remains the longest of the well-known Liverpool Marine Biological Committee (L.M.B.C.) memoirs and shows clearly his noteworthy dexterity in dissecting and illustrating. A proposed memoir on the sea lamprey, *Myxine*, became expanded into a detailed monograph and brought him into contact with Prof. G. B. Howes, whom he regarded as the most learned zoologist he had ever met and the main person to substantiate his interest in bibliography. The first part appeared in the *Transactions of the Royal Society of Edinburgh* in 1905 and was followed by five further parts which set a standard of meticulous accuracy that has not often been reached. As the result of the earlier parts of this and his other work, he received the Neill Gold Medal of the Society. While at Liverpool, arrangements were made for him to keep terms at Jesus College, Oxford, where he obtained his B.Sc., and later the University conferred on him the D.Sc.

Cole went to what was then University College, Reading, in 1905 to found a Department of Zoology, and the following year was appointed to the chair, which he held until his retirement in 1939. He threw himself whole-heartedly into the task of building up the Department and, indeed, by his example and wise counsel played an appreciable part in the development of the young University. One of his first objects was to set up a museum, which from the beginning contained deliberately chosen specimens most carefully prepared and mounted and catalogued and written up in several volumes. It formed an outstanding and widely admired feature of the Department and represented an enormous amount of hard work and thoughtful planning. He retained a connexion with Liverpool, for he continued to take his senior students to Port Erin Biological Station, and several of his students contributed important memoirs to the Liverpool Marine Biological Committee series. In 1926 he was elected a Fellow of the Royal Society.

His inquiring mind and interest in things historical turned Cole's attention to the medieval architecture of the churches in the countryside around Reading and to the writing of an interesting analysis of the church of St. Mary, Cholsey. He now devoted more attention to the bibliography and history of comparative anatomy and published a number of contributions on these subjects, including, in 1944, an important book on the "History of Comparative Anatomy: from Aristotle to the Eighteenth Century". Always interested in books, he gathered a most remarkable and valuable library in his own field, which contains a number of very rare early works and is exceptionally complete. Indeed, the museum of his Department and his library were his much-loved and cared-for 'scientific children'. His first contribution to *Nature* was in 1895, and then there was a long gap; but readers will recall the series of articles and reviews since his retirement that gave some indication of his wide knowledge and sound judgment. His particular period was the Dutch microscopists of the seventeenth century, especially Leeuwenhoek. Just before and during this time he played a much appreciated part in the development of the newly instituted subject of history and philosophy of science in the University of London. For twenty-five years he served as external examiner and for a year less as member of the Board of Studies.

He was a tall, impressive man who would have appeared somewhat forbidding if this were not contradicted by the twinkle in his eyes. Gifted with a most retentive memory and, in addition to his zoological and bibliographical lore, a good knowledge of classical music and of the old masters of the Dutch and Flemish Schools, his conversation was well worth while, particularly as it was spiced with a quiet, dry humour. His teaching was always thorough and inspiring, and his students retained a great respect and affection for him. He will retain a warm place in their memories and in those of his colleagues. He is survived by a wife and a son, to whom we offer our sincere sympathy. CHAS. H. O'DONOGHUE

Dr. Karl Jordan, F.R.S.

IT is not given to many men to cover a span of seventy years with worth-while contributions to any science. Karl Jordan's first published work was an account of the lepidopterous fauna of Göttingen, a university dissertation submitted on his doctorate. In the next three years he gave rein to his childhood passion for beetles by publishing numerous supplements to the list of beetles of Hildesheim, his home town, near which he was born on December 7, 1861. The seventh son of a small farmer, Heinrich Ernst Karl Jordan had many duties to perform, besides going to school; but it was while going about these tasks that he had become interested in insects. He often related that the Carabidae in particular fascinated him. It was not just because they varied so much in colour, nor was it the mechanism of this variation that attracted him; the great question was 'why' did they vary. It is this theme that runs like a thread through all his writings.

At Göttingen he had been awarded the coveted *Summa cum Laude* in botany and zoology and afterwards obtained a diploma in teaching—a fact which his own daughters learnt later to appreciate. A year of voluntary military training was followed by appointments in the grammar school at Münden and at the School of Agriculture at Hildesheim. In 1891 he was able at last to marry the girl who had waited for him since both were in their 'teens; their marriage could not have been happier.

At the age of thirty-two, already with wide experience behind him, Jordan seemed set for a distinguished academic career. It was then that chance brought him in contact with Ernst Hartert, who had just been appointed by Walter (later Lord) Rothschild to be director of the Zoological Museum which he had formed at Tring—in two small cottages. Jordan's first task on arrival at Tring was to reduce to order the immense but chaotic collection of beetles (the Lepidoptera were already in better shape) stored in various parts of Tring, without proper working conditions or even a microscope. It was just what he wanted, a marvellous enforced exercise in the study of geographical variation, and any odd corner served as a bench. However, it soon became apparent that not even his devoted labours, carried far into the night, could cope with both the Coleoptera and the Lepidoptera at Tring, and before long the collection of the former was abandoned, except the Anthribiidae, a group of weevil-like beetles the complexity of which never ceased to fascinate Jordan, and on which alone he published more than eighty papers.

Meanwhile, Walter Rothschild, who was deeply involved in a systematic revision of the swallow-tail butterflies of the Oriental Region, enlisted Jordan's help. In a long introductory passage, Jordan (1895) proved himself some fifty years ahead of his time: he clearly appreciated the importance of populations as basic taxons, distinguished between individual, environmental and geographical variation, according the last firmly and precisely subspecific rank and applying a trinomial system of nomenclature exclusively to it. Here, too, he recognized the importance of the type system. During the next ten or twelve years other similar monographs appeared, on the hawk-moths, on the American swallow-tails, on the genus *Charaxes*, on certain families of emperor moths. These impressive monographs were built soundly on the most painstaking attention to detail, whether concerned with morphological minutiæ, distribution or bibliography; all the essential evidence available at the time, and a very great deal of entirely new and original matter, were welded together concisely in masterly fashion. However, this systematic work was by no means an end in itself.

Simultaneously, Jordan was publishing on pure morphology, on sense organs, on mimicry among butterflies and its significance for evolution, on geographical variation in relation to evolution, on 'mechanical' selection, and so on. Throughout his writings there is the constant theme that experimental biology and systematics are interdependent; neither can be complete, or even wholly dependable, without the other. The study of systematics was to him a means for proving the truth of evolution, and, as another writer has said, he "exerted an influence on the development of systematics and on evolutionary thought that cannot be over-estimated". It is quite possible, however, that his unpublished influence was equally great, for no one could have been more generous than Jordan in the inspiring help he gave so freely to his innumerable correspondents in all parts of the world.

At the age of seventy-four, Jordan made his first really ambitious collecting expedition, to South West Africa. When well over eighty, he remarked that it was time he started on his catalogue of fleas, a task he felt he owed to Charles Rothschild. The story of their fruitful co-operation has been told elsewhere; it was left to Miriam Rothschild, one of his most ardent disciples and admirers, to undertake this task, with the help of the Trustees of the British Museum. On his ninety-fourth birthday the Royal Entomological Society of London published a special volume in his honour, an event unique in its history and more significant an indication of the esteem in which he was held than anything these few words can convey. My own lasting impression is one of effervescent enthusiasm, intense interest in discovery and in the future, of the unexpected wit with which he would enliven a dull discussion, of his unfailing, unstinted help and kindliness, and of the fruitfulness of his long and happy life. He died on January 12, in his ninety-eighth year. N. D. RILEY

Dr. J. Travis Jenkins, O.B.E.

DR. JAMES TRAVIS JENKINS died on January 12, at his home, Henbant Hall, Capel Dewi, Llandyssul, Cardiganshire. Born in 1876, the son of a schoolmaster, he attended school first at Pontardawe, Glamorgan, and then at the Merchant Venturers' School, Bristol. Afterwards he attended the University Colleges of Aberystwyth and Cardiff, and in 1897 graduated B.Sc. of the University of Wales. Only three years afterwards (1900) he was awarded the doctor of science degree of the University of Wales for a thesis on the anatomy of the oyster. His early preoccupation with marine zoology, and particularly with its economic aspects, was also shown in his work at Kiel, where a year or two later he was awarded a doctorate of philosophy.

In 1904 Jenkins was appointed superintendent of the Lancashire and Western Sea Fisheries Joint Committee, and this post he held until his retirement in 1946, except for a short period during 1908–10, when he was seconded to the Bengal Government to investigate and organize the fisheries of the Bay of Bengal. On Indian fishes and fisheries he published a number of papers, some under the seal of the Bengal Government, others in the *Records of the Indian Museum*. He retained his interest in the subject in later years, and even so late as 1938 an article by him on "The Fisheries of Bengal—Can they be Developed and Improved?" appeared in *Current Science*.

As superintendent of the Lancashire and Western Sea Fisheries Joint Committee, Jenkins was responsible for a long series of quarterly reports dealing with the mussel, cockle and other fisheries of the Committee's district and with the various laws and regulations relating to these. In addition to his scientific qualifications, he was admitted a barrister of Gray's Inn in 1910. He acted for many years as honorary secretary of the Association of Sea Fisheries Committees of England and Wales. His work for the inshore fisheries was recognized by his appointment as O.B.E. in 1941.

He will be chiefly remembered for a series of books relating to fisheries and fishes: "The Sea Fisheries" (1920); "A Textbook of Oceanography" (1921); "A History of the Whale Fisheries" (1921); "The Herring and the Herring Fisheries" (1927); "Whales and Modern Whaling" (1932); and, best known of all, "The Fishes of the British Isles", the first edition of which appeared in 1925 and the second in 1936. He had always a keen interest in the historical and literary aspects of the fishing industries, and his last publication, issued in 1948 by the Society for the Bibliography of Natural History, was a comprehensive "Bibliography of the Whale Fisheries".

Jenkins was for many years a member of the Council of the National Museum of Wales. I recall with appreciation not only his many donations of specimens to the Zoology Department of the Museum but also his companionship both abroad and on collecting trips on board the Lancashire and Western Committee's steamer, the S.S. *James Fletcher*.

COLIN MATHESON

Mrs. E. W. Sexton

THE death occurred on February 18, at the home of her son at Alfriston in Sussex, of Mrs. Alice Wilkins Sexton, at the age of ninety. Although without scientific academic training, Mrs. Sexton (known under her adopted initials of 'E. W.') became an authority of international repute on Crustacea. Living at Plymouth, where her husband was a dentist, she began to work at the Laboratory of the Marine Biological Association at the beginning of this century under the guidance of the late Dr. E. J. Allen, for whom she made beautiful drawings of polychætes. Later, she was appointed a member of the scientific staff of the Plymouth Laboratory.

She was most noted for her systematic work on amphipods, and for the detailed study she made of the growth, moulting, intersexes and genetics of *Gammarus*. In the latter she concentrated especially on eye colour. The names of her species, *Gammarus chevreuxi* and *G. zaddachi*, are well known to biologists. All her publications were accompanied by examples of her meticulously careful and accurate drawings, which were at times astonishing in their detail.

A woman of remarkable vitality, she had many interests, notably the cultivation of unusual plants from many countries. Until she had to leave Plymouth in 1957 owing to failing eyesight her hospitable home, with its many and varied treasures, had been open to a very wide circle of friends from Britain and elsewhere.

Mrs. Sexton was a Fellow of the Linnean Society. She leaves a married son, Col. F. B. W. Sexton; her daughter Mary, who was librarian at the Plymouth Laboratory, died in 1951.

F. S. RUSSELL

NEWS and VIEWS

Pharmacology at Oxford: Prof. J. H. Burn, F.R.S.

JOSHUA HAROLD BURN has been professor of pharmacology in Oxford since 1937. His restless energy has built the most active pharmacological department in the world. Many of his students have learned to do accurate experiments and to write clear papers. He has attracted workers from many countries, who came to learn the techniques of which he is master. He is retiring at the age of sixty-seven, but shows no sign that his mind is less active than it was. He was educated at Barnard Castle School, University of Cambridge, and Guy's Hospital, London. Like many others, he derived inspiration from H. H. Dale, with whom he worked before the First World War at the Wellcome Physiological Research Laboratories, and then, after service in the Royal Engineers, in the National Institute for Medical Research. In 1926 he became professor of pharmacology in the College of the Pharmaceutical Society and director of a laboratory which undertook the biological standardization of drugs on a large scale. He wrote a book which laid the foundations of accurate methods of assay, and he has written at least half a dozen other books on various aspects of pharmacology, and large numbers of scientific papers, lectures, reviews, editorials and reports of various kinds. He makes up his mind and puts his thoughts on paper without trouble or delay, and has provided a very potent stimulus to the development of pharmacology. His work has been concerned with all classes of drug, but has been especially important when he has used pharmacological methods to solve physiological problems.

Prof. W. D. M. Paton, F.R.S.

WILLIAM DRUMMOND MACDONALD PATON succeeds Burn as professor of pharmacology at Oxford. He was born in 1917 and educated at Repton School, the University of Oxford, and University College Hospital, London. He joined the staff of the National Institute for Medical Research in 1944. During his eight years there he made his name by two outstanding pieces of work. With F. C. MacIntosh he showed that various simple organic bases cause the release of histamine, which disappears from the tissues of animals. It has thus been possible to study not only the mechanisms of release, but also the effects of removing most of the histamine, which are surprisingly small. With E. Zaimis he discovered not only that small doses of decamethonium cause neuromuscular blockade by depolarizing the end plate, but also that hexamethonium blocks transmission through autonomic ganglia. The analysis of the mode of action of these drugs by these two workers became a model for such studies. Hexamethonium was the first drug shown to have a really powerful and specific action on peripheral autonomic ganglia. It has been invaluable as a research tool, but it is best known as the basis of the first really effective treatment for high blood pressure. This was a major advance in therapeutics and led to the award of the Cameron Prize to Paton and Zaimis in 1956. In 1952 Paton went as reader to University College and in 1954 he was appointed to the newly founded chair of pharmacology at the Royal College of Surgeons.

Organic Chemistry at Birmingham : Prof. J. C. Tatlow

As part of the large expansion programme of the Department of Chemistry at the University of Birmingham, a new chair of organic chemistry has been created. Dr. J. C. Tatlow, at present reader in organic chemistry in the Department, has been appointed to be the first holder of the chair. Dr. Tatlow entered the University of Birmingham in 1940 to read chemistry with county major, State and Rugeley Grammar School scholarships. He was Burstall Prize-man in 1941 and Frankland Prize-man in 1943, when he gained his B.Sc. with first-class honours. He obtained the Brotherton Research Scholarship and was appointed to the staff of the Department of Chemistry in 1944 as leader of a research group engaged on fluorine and uranium chemistry. In 1946, after gaining his Ph.D., he was appointed scientific officer in the Ministry of Supply at the Chalk River Atomic Energy Establishment in Ontario. He returned to Birmingham in 1948, first as an Imperial Chemical Industries Fellow and later as lecturer in chemistry. Since that time he has led a large team engaged in the chemistry of organic compounds and is joint or senior author of some seventy original papers in that field. He was awarded his D.Sc. in 1954 and his Fellowship of the Royal Institute of Chemistry in 1955. He has for many years been a member of the Midlands Section of the Royal Institute and a local representative of the Chemical Society. He was appointed a member of the Council of the Chemical Society in 1957. He is playing a prominent part in organizing the First International Congress on Fluorine Chemistry to be held in Birmingham in July next. He was appointed senior lecturer in chemistry at Birmingham in 1956 and reader in organic chemistry in 1957. He has had wide teaching and organizing experience and is a member of the Pure Science Board of Examiners. He has played a major part with Prof. M. Stacey and Prof. J. C. Robb in the design and planning of the new chemistry buildings at Birmingham.

Engineering Production at Birmingham : Prof. N. A. Dudley

Dr. N. A. Dudley, recently reader in engineering production and head of the Department of Engineering Production in the University of Birmingham, has been appointed to the chair in that subject at Birmingham. Dr. Dudley was born in 1916 and educated at King's Norton Grammar School and Birmingham Central Technical College. Before his appointment in 1945 as lecturer in production engineering and management at Burton-on-Trent Technical College, he was a production engineer in industry. In 1947, he became a member of the staff of Birmingham Central Technical College, and during 1948–52 he was senior lecturer in the Department of Engineering Production at Wolverhampton and Staffordshire Technical College. He was then appointed lecturer in engineering production in the University of Birmingham and in 1956 was made reader and head of the Department of Engineering Production and also head of the Institute for Engineering Production.

Nuclear Science and Technology at the Royal Naval College, Greenwich : Prof. J. Edwards

Mr. J. Edwards, senior principal scientific officer and head of the Naval Section at the Atomic Energy Research Establishment, Harwell, has been seconded from the Royal Naval Scientific Service, and appointed to the new chair of nuclear science and technology, recently established at the Royal Naval College, Greenwich. During his four years at Harwell, Mr. Edwards was responsible for the extensive programme of experimental work which has been carried out by the Atomic Energy Research Establishment and the naval scientists there and he has, therefore, a wide experience of reactor systems cooled and moderated with ordinary water, and the general problems involved in the small reactor plants likely to be suitable for mobile purposes. He has twice visited the United States in connexion with these developments and last year delivered a lecture on the prospect of nuclear propulsion to the Engineering Section of the British Association in Glasgow. He was also one of the Admiralty delegates to the recent Geneva Conference on the Peaceful Applications of Nuclear Energy. Prof. Edwards served his engineering apprenticeship in Chatham Dockyard and obtained a Whitworth Scholarship to the City and Guilds College of the University of London, where he took an honours degree in engineering. He has since served in a variety of Admiralty research establishments including the Torpedo Experimental Establishment, the Admiralty Engineering Laboratory, where he was concerned with detailed stress and vibration investigations and gas turbine analyses, and the Department of Engineering and Materials Research in charge of studies and experimental work on advanced propulsion systems. In 1953 he was appointed to the staff of the Commander-in-Chief, Home Fleet, as scientific advisor concerned with operational research problems, serving in this capacity for some fifteen months in both H.M.S. *Vanguard* and H.M.S. *Tyne*. He has also been concerned with tripartite negotiations leading to standardization in the shock and vibration field.

Research Laboratory, British Museum : Dr. H. J. Plenderleith, C.B.E.

Dr. H. J. Plenderleith has retired from the keepership of the Research Laboratory of the British Museum, Bloomsbury, to become the first director of the International Centre for the Study of the Conservation and Restoration of Cultural Property, in Rome. After distinguished service in the First World War, he joined the British Museum Laboratory under the late Dr. Alexander Scott, succeeding him in course of time as head of the Department. The Laboratory now has an international reputation, and its advice is sought over an extremely wide range of objects and their care. When the Honorary Scientific Advisory Committee of the National Gallery was formed in 1935, Dr. Plenderleith was one of its original members and was chairman during 1944–58. In 1936 he succeeded the late Prof. A. P. Laurie at the Royal Academy, retiring from the chair of chemistry there last year. During 1950–58 he served the International Institute for the Conservation of Museum Objects as its first honorary treasurer, and is now a vice-president. The author of numerous publications and lectures, Dr. Plenderleith has collected the results of more than thirty years work in his book, "The Conservation of Antiquities and Works of Art", published in 1956. There are few countries which Dr. Plenderleith has not visited, and he was a member of the van Meegeren Commission in 1947. He is now chairman of the Museums

Laboratories Committee of the International Council of Museums, which meets in Copenhagen this coming summer. In 1934 he was elected a Fellow of the Royal Society of Edinburgh, and in 1956 he received the honorary degree of LL.D. from his old University, St. Andrews. He brings high distinction, both scientific and administrative, to his new office.

Dr. A. E. A. Werner

Dr. A. E. A. Werner, who succeeds Dr. H. J. Plenderleith as keeper of the Research Laboratory of the British Museum, Bloomsbury, was born in Dublin in 1911. He was educated at Trinity College, Dublin, and at the University of Freiburg-im-Breisgau, where he was awarded the degree of D.Phil. In 1937 he was appointed lecturer in organic chemistry in the University of Dublin, and in 1948 went to London as the first holder of the post of research chemist (senior scientific officer) in the Scientific Department of the National Gallery. In 1954 he transferred to the British Museum, as principal scientific officer. Dr. Werner has made a special study of the application of new synthetic materials to the conservation of works of art and is undertaking a detailed report upon adhesives to the Museums Laboratory Committee of the International Council of Museums, of which he is a member. For some years he has given valuable help to the Wall-Paintings Committee—a joint body set up by the Central Council for the Care of Churches, and the Society for the Protection of Ancient Buildings—to deal with the care of murals in Great Britain. In collaboration with J. S. Mills, he has made use of chromatographic techniques in the study of the natural resins. With his gift for languages and wide cultural interests, in addition to his scientific accomplishments, Dr. Werner is assured of the best wishes of a wide circle of friends and colleagues, both in Britain and abroad, as he enters upon his new responsibilities.

The Wykeham Chair of Logic at Oxford : Prof. H. H. Price

In October, Prof. H. H. Price will be succeeded in the Wykeham chair of logic at Oxford by Prof. A. J. Ayer, at present Grote professor of the philosophy of mind and logic, University College, London. Prof. Price, who was appointed to the chair in 1935 from a fellowship in philosophy at Trinity College, Oxford, began his philosophical career as an admirer of Prichard, Cook Wilson's most original and penetrating adherent. But in his first book, Perception" (1932), he expounded an essentially phenomenalist theory of perception, identifying material objects with families of sense-data, which was remote from Prichard's views. It was, in fact, a uniquely thorough and coherent articulation of the ideas about perception that had been put forward, in a comparatively tentative and unfinished way, by Russell and Moore in the preceding decades. It remains a standard work on the subject. In 1940 he published "Hume's Theory of the External World", not so much a commentary as a set of ingenious variations on the Humean theme that the conception of a material object is a construction out of sensory elements. Since 1945 Prof. Price's main publications have been in the domain of philosophical logic. "Thinking and Representation", his British Academy Lecture of 1946, foreshadowed the full-scale study, "Thinking and Experience" (1953), in which, among a great deal of careful and valuable analysis, the existence of imagery was resolutely defended against doubting linguistic philosophers, though their main point, that imagery could not be identified with the meaning of the words whose use it was associated with, was conceded. For many years Prof. Price has been actively interested in psychical research. He has considered the philosophical implications of its purported findings in a number of articles and has served as president of the Society for Psychical Research.

Prof. A. J. Ayer

Prof. Ayer's first book, "Language, Truth and Logic" (1936), which became well known outside the philosophical world for the vigour of its onslaught on metaphysics, traditional ethics and theology, was a presentation to the English-speaking public of the ideas of the Vienna Circle of logical positivists. It was also a more far-reaching piece of anglicization, since it applied techniques and principles worked out for the logical analysis of science to the analysis of knowledge in general. The thoroughgoing phenomenalism briefly sketched in it was more fully developed in "Foundations of Empirical Knowledge" (1940), which, its author states, owes more to Price's "Perception" than to any other work. Just as Prof. Ayer was prepared to go further than Prof. Price here by entirely rejecting material substance as something over and above actual and possible sensation, so, in "Thinking and Meaning", his inaugural lecture, delivered at University College, London, in 1947, he discarded the last relics of realism about universals which still figure in Prof. Price's examination of the same issue. In "Philosophical Essays" (1954) he collected a dozen substantial articles on philosophical logic, theory of knowledge and ethics. "The Problem of Knowledge" (1956), though designed as an introduction to philosophy, presents original contributions to the problems of perception, memory, the self and other minds.

Both Price and Ayer are masters of the lucid exposition of abstract subjects. Price's writing is notable for its charm and quiet humour, Ayer's for its brilliant concision and elegance. In Ayer's succession to Price the continuing strength and vitality of the British empirical tradition in philosophy is recognized.

Corday–Morgan Medal and Prize : Prof. G. W. Kenner

Prof. G. W. Kenner, Heath Harrison professor of organic chemistry in the University of Liverpool, has been awarded the Corday–Morgan Medal and Prize for 1957 for his contributions to synthetic organic chemistry, particularly in the field of peptide and nucleotide chemistry. This award, consisting of a silver medal and a monetary prize of 200 guineas, is made annually to a British chemist of less than thirty-six years of age, who, in the judgment of the Council of the Chemical Society, has published during the year the most meritorious contribution to experimental chemistry. Applications or recommendations in respect of the award for the year 1958 must be received not later than December 31, 1959, and applications for the award for 1959 are due before the end of 1960. Copies of the rules governing the award may be obtained from the General Secretary, Chemical Society, Burlington House, London, W.1.

Institute of Metals Medals

The Council of the Institute of Metals has made the following awards of medals: *The Institute of Metals (Platinum) Medal* to Dr. L. B. Pfeil (director, Mond Nickel Co., Ltd.) in recognition of his outstanding contributions to non-ferrous metallurgical science and to the non-ferrous metals industries; *The Rosenhain Medal* to Prof. R. W. K. Honeycombe (professor of physical metallurgy, University of Sheffield) in recognition of his outstanding contributions in the field of physical metallurgy; *The W. H. A. Robertson Medal and Premium* to Dr. R. B. Sims (chief engineer, Davy and United Engineering Co., Ltd.) for a paper on "Automatic Gauge Control in Rolling Mills", published in the *Journal of the Institute of Metals*, 86 (1957–58).

World Life Research Institute

Bruce W. Halstead, formerly of the School of Tropical and Preventive Medicine, College of Medical Evangelists, Loma Linda, California, has recently been appointed director of the World Life Research Institute now under construction in Reche Canyon, Colton, California. The new institute will be operated as a non-profit-making, scientific and educational organization with emphasis on fundamental research in the broad field of the chemistry of natural products; for example, phytochemistry and marine biotoxicology. The application of these compounds to medicine and industry is also of direct interest to the organization. Research will be conducted under contract and grants-in-aid from government and industry. A technical assistance programme will be developed, working in conjunction with certain under-developed countries, in the chemistry of natural products.

Colonial Development and Welfare

In moving the second reading of the Colonial Development and Welfare Bill in the House of Commons on March 2, the Secretary of State for the Colonies, Mr. A. Lennox-Boyd, said that the background to the Bill was explained in the report on the use of funds provided under the Colonial Development and Welfare Acts and outline of the proposal for exchequer loans to the Colonial territories issued as a White Paper (Cmnd. 672). The first part of the Bill extends the period of the existing Colonial Development and Welfare Acts and increases the money available for schemes made under the Act. All but 2 per cent of the money provided under the Acts had been in the form of grants, and expenditure was now running at over £12 million a year; from April 1946 to March 1958 it totalled £155,418,000. Of this, £13,255,000 was for research, for which commitments in the period totalled £17,203,000 or 8·9 per cent of the total, while a further 21·2 per cent was for communications, 14·2 per cent for agriculture, fisheries and forestry, 4·4 per cent for irrigation and soil conservation and 18·3 per cent for education. The latter figure included grants of £1,244,250 to the University College of Rhodesia and Nyasaland and £1,500,000 to the University of Malaya. Although some of the territories had now become self-governing Dominions, which under Clause 2 (7) of the Bill would cease to be eligible for Colonial Development and Welfare assistance, over the whole field more than four times as many administrative, technical and professional officers are being recruited than before the War. Mr. Lennox-Boyd referred particularly to the value of the work of the technical advisers to the Federal Government of the West Indies.

The Bill would provide £95 million of new money over the next five years, compared with £80 million made available in 1955 on the present quinquennium. Excluding the £24 million to be allocated to Malta but including the £44 million unexpended under the previous Acts, this would give £115 million for spending in the five years from April 1, 1959. In several territories the immediate effect of development has been to increase the demand on Government resources, and as external financial aid, mainly from the United Kingdom, is likely to be needed for many years the Bill introduced a novel plan of Exchequer loans. Provision was made for up to £100 million of such loans from the Government fund, over five years normally, to meet the cost of the loan-worthy element to general development programmes. The terms of these Exchequer loans will be fixed by the Secretary of State for the Colonies with the approval of the Treasury, but will not be more favourable than those on market issues. Mr. Lennox-Boyd said that the Bill was the next step in a programme of continuous assistance to Colonial governments and believed that it could facilitate a substantial expansion in development.

Funds for Commonwealth Students in Britain

In a statement circulated in *Hansard* for March 9, the Under-Secretary of State for Commonwealth Relations, Mr. C. J. M. Alport, said that of the £620,500 from United Kingdom Government funds available to Commonwealth and Colonial students in 1958–59 for study in the United Kingdom, £180,000 is under Colonial Development and Welfare, £315,000 under the Colombo Plan Technical Co-operation Scheme, £66,400 for British Council scholarships and bursaries, £4,500 under technical assistance to Ghana, £600 for the Federation of Malaya Merdeke Scholarship, £4,000 under Baghdad Pact technical assistance and £50,000 for Athlone fellowships. These funds are not necessarily restricted to university students but are available for further education or training at any suitable centre in Great Britain. In addition, a wide range of scholarships tenable in Britain is offered by the United Nations Special Agencies, charitable and educational trusts, universities, business firms and others.

Nato Studentships and Fellowships

In a written answer in the House of Commons on March 2, the Parliamentary Secretary to the Ministry of Works, Mr. H. Nicholls, representing the Lord President of the Council, said that the North Atlantic Council had decided to finance a science studentship and fellowship programme to start this year. The Department of Scientific and Industrial Research, in consultation with other interested Government bodies, would make these awards to British subjects normally resident in Britain. Under the programme the United Kingdom proposed to provide increased opportunity for study, research training and experience for postgraduate and postdoctoral students in science and technology (including medical and agricultural sciences, industrial psychology and sociology). The scheme was intended to stimulate international exchange of such students between North Atlantic Treaty Organization countries, but awards could be held in the home country of a student or in a country which was not a member of the Organization. The value of the awards and their conditions would be generally similar to those for studentships and fellowships of the Department of Scientific and Industrial Research.

Power Stations in Britain

In moving the second reading of the Electricity (Borrowing Powers) Bill in the House of Lords on March 3, the Minister of Power (Lord Mills) said that apart from the hydro-electric plant in the North of Scotland's programme, practically all the new generating plant, with a total capacity of 12·25 million kilowatts, which the Electricity Council intended to provide, would be coal-fired or nuclear, and it was estimated that nuclear power would absorb 47 per cent of the £1,100 million which the Central Electricity Generating Board proposed to spend on power-station construction. Of investment in power stations proposed over the next seven years, less than 4 per cent represented oil-fired plant, and within the past week, by agreement with the oil companies and the National Coal Board, conversion of two power stations from coal to oil would be postponed for a year. At present there were five consortia of firms with design teams trained by the Atomic Energy Authority and capable of tendering for the construction of complete nuclear power stations. As the number of nuclear power stations that will be built in Britain before 1966 will not now exceed twelve to fourteen, the opportunities for a new consortium will be somewhat limited in future, although there were opportunities here and overseas for the manufacture of small reactors, including research reactors. If a British firm could obtain permission to make use of, say, American development work so that it could sell in export markets reactors of a different type from those developed here, he saw no reason why it should not do so.

Dealing with distribution, on which expenditure totalling £700 million was proposed for the seven years, Lord Mills said that at present nearly 75 per cent of farms had a supply of electricity, and the programme as a whole was expected to be completed on time. The proposed storage scheme at Festiniog and one projected at Loch Awe would eventually provide 700 megawatts at peak hours. Other research on storage was proceeding and he was satisfied that this research programme was adequate.

University News:

London

Dr. A. R. Boothroyd, lecturer at the Imperial College of Science and Technology, has been appointed to the University readership in electronics tenable at that College; the title of reader in crystallography in the University has been conferred on Dr. C. H. Carlisle in respect of his post at Birkbeck College; Dr. R. F. Saxe, lecturer at Queen Mary College, has been appointed to the University readership in nuclear engineering tenable at that College.

Dr. B. J. Mason, Warren Research Fellow of the Royal Society at the Imperial College of Science and Technology, London, has been appointed visiting professor of meteorology by the University of California for the period June 1–December 31.

Sheffield

The University of Sheffield has received, among others, three grants from the Department of Scientific and Industrial Research: one of more than £15,000, spread over five years, to the Department of Fuel Technology and Chemical Engineering, for the study of the formation and combustion of coal smoke; a grant of £6,000 over three years in aid of its work to the School of Social Studies, to investigate the transition to work of boys and girls from secondary modern schools in the Sheffield area; a grant of £30,500 over five years to the Department of Electrical Engineering, for the study of almost fully ionized gases by millimetre wave-probe techniques, involving building a small thermonuclear reactor, like *Zeta*, in the Department.

Announcements

The Gold Medal of the Royal Aeronautical Society, the highest honour the Society can confer, for work of an outstanding nature in aeronautics, has been awarded to M. Marcel Dassault, the well-known French aircraft designer, for "his outstanding contributions to the design and development of aircraft". One of the first aircraft designed by M. Dassault was the *S.E.A.*4 in 1918, and the last aeroplane to be designed by him was the *Mirage IV*, a high-speed twin-engine bomber. Between the Wars he designed many successful French aircraft, including fighters, reconnaissance types, bombers and transports.

Prof. S. J. Angyal, head of the Department of Organic Chemistry, University of New South Wales, has been awarded the H. G. Smith Memorial Medal. The Medal is awarded every year by the Royal Australian Chemical Institute to the member who, in the opinion of the Council of the Institute, has contributed most to the development of some branch of chemical science.

The Operational Research Society has appointed Miss G. M. Heselton to be its secretary, and has moved into an office at 64 Cannon Street, E.C.4 (telephone, City 1800). The president is Prof. M. G. Kendall, of the London School of Economics, and the *Operational Research Quarterly* is published for the Society by Pergamon Press, Ltd.

Mr. Robert Douglas Baird has been appointed a director of Baird and Tatlock (London), Ltd., and of Hopkin and Williams, Ltd. Mr. Baird is a grandson of the founder of Baird and Tatlock (London), Ltd. He was educated at Winchester and Cambridge, where he read for the Mechanical Sciences Tripos. On leaving Cambridge, he joined the army in 1943; after demobilization in 1946 he returned to Cambridge to take the Certificate in Education, and since 1947 he has been teaching mathematics at Eton College, where he is also the careers master.

The Physical Society is holding a Conference on Nuclear Physics in the University of Oxford during April 8–10. The Acoustics Group of the Society is holding a Symposium on New Techniques in the Analysis of Noise and Vibration jointly with the Institute of Physics in the Physics Department, University of Southampton, on April 7. Further information can be obtained from Miss E. Miles, Physical Society, 1 Lowther Gardens, London, S.W.7.

A National Education and Careers Exhibition, organized by the National Union of Teachers, is to be held at Olympia during May 26–June 5. The Education Section will display all aspects of modern education from nursery school to university and adult education. The Careers Section will offer information and advice on careers in virtually all the main fields of employment. Inquiries should be directed to the National Education and Careers Exhibition Office, Hamilton House, Mabledon Place, London, W.C.1.

VEGETATION OF THE HUMID TROPICS

A SYMPOSIUM on "Humid Tropics Vegetation", sponsored jointly by Unesco and the Council for Sciences of Indonesia, was held during December 12–15 in the new Academy of the Ministry of Agriculture at Tjiawi near Bogor (formerly, Buitenzorg). Spacious accommodation delighted the delegates, mountain air fanned the discussions, and the wooded plain of Bogor made a fitting prospect. It was successor to the symposium on "Tropical Vegetation" held by Unesco in Kandy in March 1956. To judge from the strenuous programme, the full attendance, the vigorous exchange of views, and the unanimous decision to request a third symposium for 1960, the second was as successful as the first. Great credit for the organization must be given to Dr. Lennart Mattsson (director, Unesco South-East Asia Science Co-operation Office), Prof. Kusnoto Setyodiwiryo (director, Kebun Raya, Indonesia), Prof. Sadikin (director, Academy of Agriculture, Tjiawi), and Mr. Anwari Dilmy (director, Herbarium Bogoriense). Twenty-seven delegates attended from: Australia, Sarawak and Brunei, Cambodia, Ceylon, India, Pakistan, Singapore, Thailand, United Kingdom, United States, the Food and Agriculture Organization, and Indonesia.

Opening addresses on the first morning were given by Prof. Kusnoto Setyodiwiryo, Prof. Sarwono Prawirohardjo (president, Council for Sciences of Indonesia), Mr. Hutasoit (secretary general, Ministry of Education and Culture), and Dr. Mattsson. They set the tone of sincere appreciation of science which enabled the delegates, in the ensuing reception, to meet at once on common ground. In the afternoon and on the following days thirty-one papers were presented. These had been duplicated, bound, and distributed to delegates on arrival, so that the author was allowed some twenty minutes to review his theme and there was ample time for discussion. On the first afternoon, Prof. Kusnoto Setyodiwiryo introduced the subject of the "Flora Malesiana", as the backbone of botanical research in South-East Asia; it led to a number of resolutions concerning the progress of floristic botany in adjacent regions. Several reports were then given on ecological studies since the Kandy symposium.

The second day opened with Dr. F. R. Fosberg's (United States) presentation of a detailed classification of humid tropical vegetation based on plant characteristics without admixture of climatic and edaphic determinants. Such a purely botanical approach was welcomed, and his extensive and valiant key to vegetational categories will certainly be tested throughout the tropics. Prof. H. B. Gilliland (Singapore) described his method of evaluating and classifying secondary forests in Singapore. He championed a phase in ecology which foresters had neglected and bravely evoked the outspoken criticism which made this and succeeding discussions basic and fruitful. Dr. R. G. Robbins (Australia) gave a vivid account of vegetational mapping in eastern New Guinea by air survey and ground reconnaissance; probably no ecological work has been undertaken so rapidly and, as it appeared, so satisfactorily on so large a scale; it provided a reliable picture for land-utilization where no other survey was adequate. Mr. R. A. de Rosayro followed with a detailed account of aerial photography applied to forestry problems in Ceylon. Here, the smaller area permitted analysis with sample plots on the ground; it seemed clear that the virgin forest was in a state of dynamic equilibrium between associations dominated by *Mesua* or *Doona* and by mixed associations between them and *Shorea*. This novel theory provoked much comment; the greater variety of trees in Malaysian forests would obscure the effect. Dr. Y. Satyanarayan (India) described his method of evaluating dominance in Bombay forests by estimating crown-coverage. Dr. Robbins presented a paper by B. W. Taylor and R. O. Whyte (Food and Agriculture Organization) in which they developed the idea of a 'land-type' composed of 'land-units' as an exploitable entity; though intended for agrarian use, it became evident as discussion proceeded that such compound topographical concepts could well be applied to vegetation. Mr. Wyatt-Smith (Malaya) closed this part of the programme dealing with ecological methods by describing the Malayan forester's method of quantitative assessment of forest composition and structure. He emphasized the necessity for reconciling metric and British systems of enumeration with respect to quadrat-size and trunk-measure; a detailed resolution was afterwards taken up to this effect.

The third morning was given to papers on tropical peat-swamps, particularly of Borneo, as presented by J. H. R. Anderson, P. Shaw Ashton and A. J. G. H. Kostermans. To me this was the most interesting part of the programme for I had spent several years endeavouring to explore such forest in Malaya. To Unesco must go the credit for having first brought together experts on this peculiar, and intricate, vegetation so difficult of access. These papers and the ensuing discussion should be perused by all interested in tropical forests because the peat-swamps are an integral step in lowland forest succession; they are being exploited, and there is urgent need of study before axe and poison can destroy them for ever. Yet it was evident that here, as in many other cases, discrepancies arose not from errors in observation or from misunderstanding but from profound differences in the phytogeographical, geological and topographical nature of the regions considered, and that more intensive local study should precede generalization. In the afternoon, Mr. Kasin Suvatabandhu (Thailand) gave an account of Thailand forests, which are of great interest because of their marginal position both in the ecology and the floristics of the humid tropics; he pointed out that there was as yet no adequate definition of the humid tropics. Dr. Robbins concluded this session with a provocative new classification of mountain vegetation derived from his researches in the central highlands of eastern New Guinea. As this adds a new range to ecological knowledge of tropical mountains, his conclusions will be widely discussed. He proposed to get rid of the term 'mossy forest' and a resolution to this effect was approved; but reflexion leads me to conclude that this meaningful expression is still applicable where mountains do not partake in a 'central highland'.

The last morning continued with ecological problems. Dr. H. C. Trumble (Food and Agriculture Organization) described the climate of Indonesia in relation to vegetation and showed the necessity for many more meteorological records. His careful analysis should be read in conjunction with the 'land-systems' of Taylor and Whyte, for bioclimatology must complement their biotopography. Dr. Satyanarayan reviewed in detail the vegetation of the Western Ghats, where, as in Thailand, there is a transition from true humid tropical forest to the sub-arid. His account will be a standard reference for phytogeographers. Dr. Robbins then presented a paper by L. J. Webb on the rain-forest of Queensland; the importance of lianes was emphasized in the definition of forests, and the neglect of them shows how much is yet to be added to tropical ecology. Mr. Womersley gave an account of the work of the Botanical Division of Forestry in eastern New Guinea, and a second paper on the *Araucaria* forests in which he developed the theme that they were relics of ancient, even mesozoic, pre-angiosperm vegetation surviving fitfully in some unknown, possibly catastrophic, manner in the invading sea of broad-leafed forest. I think this paper will become a classic. Mr. P. R. Wycherley (Malaya) gave an elegant sketch of the ruderal behaviour of *Croton hirtus*, and a valuable analysis of an acre of forest in Malaya, such as will become a standard of reference for Malaysian ecologists. The afternoon was devoted to problems of sylviculture in Indonesia, presented by Mr. Mursaid, and in Malaya, presented by Mr. Wyatt-Smith. Striking differences were apparent, especially from the methods described for Ceylon by Mr. de Rosayro, and it was clear, again, that generalization could be misleading. In the evening Dr. Fosberg, as *rapporteur général*, gave an able summary of the proceedings, and closing speeches were made by Prof. Kusnoto Setyodiwiryo and Mr. Sudiman (secretary, Council for Sciences of Indonesia).

After the symposium delegates were taken under the leadership of Dr. A. J. G. H. Kostermans (Indonesia) to the mountain garden and nature-reserve of Tjibodas, to the Botanic Garden at Bogor, for a four-day excursion to the nature reserve of Udjong Kulon at the south-west corner of Java, and on a ten-day excursion to central and eastern Java and to Bali. Few delegates, unfortunately, had time for this trip, but that to Udjong Kulon in the research ship of the Kebun Raya gave them the unforgettable scene of Krakatoa, as the ship sailed about 8 a.m. between the new erupting cone and the old forest-clad mountain-side.

As one whose presence was fortunate rather than premeditated, I may make a few detached remarks. Such a small symposium of picked experts, discussing their problems in such hospitable, if remote, circumstances must always be rewarding. Its success depended in no small measure on the accomplishments of a few delegates, particularly Dr. Robbins and Mr. de Rosayro, who entertained us in the evening. At Tjiawi, we had an audience of students, and the proceedings, instead of being merely documented and shelved, may grow up in receptive minds. Malaya gave a good lead in sending both senior and junior delegates. We should remember these ingredients that the next may be as successful. E. J. H. CORNER

PRECIPITATION IN ALLOYS

FROM the early investigations of Wilm on the age-hardening of aluminium alloys, the study of the decomposition of supersaturated solid solutions has made rapid progress. For the past twenty years the subject has advanced largely through investigators using X-ray diffraction techniques, but within the past two years the pre-eminence of these techniques in this field has been challenged by investigators using the electron microscope to examine metals either directly by transmission or with the aid of extraction replicas. At a conference held at the Institution of Civil Engineers in London on November 28, and organized by the X-ray Diffraction and Electron Microscopy Groups of the Institute of Physics, an opportunity was given for the two groups of investigators to meet, outline their methods of approach and discuss the results obtained.

The conference comprised four principal papers—two devoted to results obtained by X-ray diffraction and two to results obtained by electron microscopy—followed by a general discussion. The first speaker was Prof. A. Guinier (Department of Physics, Conservatoire des Arts et Métiers, Paris), who described the structures of age-hardened alloys in the pre-precipitation stage. He first defined the Guinier–Preston zones in terms of the interface between the zones and surrounding matrix, pointing out the requirements for coherence. He then reviewed the evidence from which it has been possible to deduce the shape, size and structure of zones in various alloys based on aluminium and containing copper, silver, magnesium, silicon, germanium and zinc. In discussing the structure of zones in relation to the properties of alloys, Prof. Guinier pointed out that a change from a purely metallic to partially covalent or ionic bonding may occur as the zones increase in size and thickness.

The results obtained on the same series of alloys, but after examination by transmission electron microscopy, were described by Dr. J. Nutting (Department of Metallurgy, Cambridge). He showed how the predictions made from X-ray diffraction results have been confirmed by electron microscopy. He then went on to outline how the strain fields surrounding coherent precipitates may be observed and to discuss the transition from coherency to partial coherency at the precipitate–matrix interface. The advantages of the electron metallographic approach in revealing precipitate morphology were stressed and the importance of this morphology in relation to mechanical properties was briefly mentioned. The disadvantages of the electron metallographic approach is that it gives no clear indication of the zone and precipitate structure. The possibility of using selected area transmission electron diffraction was suggested as a means of overcoming this difficulty.

An account of her investigations on precipitation in aluminium alloys when using X-ray diffraction techniques was given by Miss J. M. Silcock (Fulmer Research Institute, Stoke Poges, and Department of

Metallurgy, Liverpool). She showed how the addition of small amounts of cadmium to an aluminium–copper–magnesium alloy leads to the formation of a superstructure with cadmium atoms around the edge of the plate-like zones which prevent their further growth. The structure of the zones in aluminium–copper alloys to which lithium and indium have been added was then described. The influence of cold work upon subsequent precipitation phenomena is a topic of great theoretical and practical interest. Miss Silcock reviewed some of the earlier investigations in this field and then described results she had obtained which indicate that prior cold work limits the number of orientations in which the θ′ phase forms on aging aluminium–copper alloys. Cold-worked aluminium–copper alloys containing cadmium behave in the same way as alloys free of cadmium, an effect which was attributed to an association between the cadmium atoms and the extra vacancies introduced during deformation.

The study of precipitation phenomena in steels has lagged far behind the work on light alloys. The main reasons for this are that X-ray techniques are not readily applicable to the early stages of the precipitation reactions since it is impossible to prepare single crystals of martensite, while at the later stages, bulk chemical extraction techniques followed by X-ray diffraction of the extracts serves only to identify the phases and gives no idea of the size, shape and distribution of precipitated particles. With the aid of extraction replicas and the electron microscope, the study of precipitation reactions in steels has greatly advanced, and recent results obtained in this field were described by Prof. R. W. K. Honeycombe (Department of Metallurgy, Sheffield). He described the morphological changes associated with the decomposition of martensitic plain carbon steels and then discussed the modifications introduced by the addition of strong carbide-forming elements, contrasting the different effects of chromium, molybdenum and vanadium, and the influence of small additions of niobium and tantalum. Precipitation in austenitic steels has not been studied in as great detail as that in ferritic materials, but Prof. Honeycombe described some new results on the formation of chromium carbides and niobium carbides in a standard creep-resistant austenitic steel.

The discussion which followed the principal papers was concerned mainly with the presentation of new results obtained by electron microscopy. Miss K. B. Day (British Aluminium, Gerrards Cross) put in a plea for the retention of the oxide replica technique for studying precipitation in aluminium alloys, illustrating the many advantages of the technique for investigating the advanced stages of precipitation reactions. P. M. Kelly (Cambridge) described how he had been able to prepare thin foils of steel from bulk material which were suitable for examination by direct transmission in the electron microscope. The results he obtained on high-carbon martensites and tempered plain carbon steels were illustrated. A film on precipitation in an aluminium–4 per cent copper alloy was shown by G. Thomas and M. J. Whelan (Cambridge). The film was obtained by aging thin foils of the alloy on a heating stage in the electron microscope and recording the structural changes as observed on the viewing screen with a cine-camera. The film showed conclusively that the final stages of aging involved the resolution of small particles and growth of large particles of the θ-phase.

A number of contributors presented results on the precipitation of vacancies in pure metals and alloys. R. E. Smallman (U.K. Atomic Energy Authority, Harwell) showed electron micrographs of the effects produced when vacancies were precipitated from nickel, copper, silver and gold and discussed the results obtained in terms of the energies of stacking faults in the respective metals. P. B. Hirsch (Cambridge) presented similar results and gave an account of the formation of tetrahedral stacking faults in gold. The formation of dislocation spirals by the condensation of vacancies on screw dislocations in an aluminium 4 per cent copper alloy was described by M. J. Whelan and G. Thomas (Cambridge). These spiral dislocations provide favourable sites for the nucleation of precipitates and are responsible for the structures shown by Mme. A. R. Weill (Paris) of abnormalities in the distribution of the θ′ precipitates after aging.

The object of the conference, in attempting to bring two groups of workers together, was admirably conceived; the fruits of this union will be awaited with interest. For the electron microscopists at least the agreement between their results and those obtained by X-ray diffraction was reassuring, and vindicated their efforts of the past few years in the development of the thin-foil techniques for the direct examination of metals by transmission.

J. Nutting

FUEL RESEARCH

THE report of the Fuel Research Board for 1957*, issued on October 31, 1958, is particularly noteworthy for the fact that it records the decision to close down the Fuel Research Station at Greenwich, and transfer to the new Warren Springs Laboratory at Stevenage only two main items of research. These are the programmes of work concerned with the measurement and abatement of air pollution and with the synthesis of oil from carbon monoxide and hydrogen, which are obtained from the gasification of coal.

In recent years quite a number of other organizations have also been concerned with research on fuels, most of them in connexion with more or less specialized aspects of fuel technology and its associated bearing on industrial practice.

The new laboratory at Stevenage is envisaged as the centre of research in Britain on air pollution, though again many aspects of the problem associated with processing must necessarily rest to some degree in the domain of other organizations. The co-operative scheme for the measurement of pollution together with the collection and analysis of the results will also be continued at Stevenage. A new and much required programme of research will be undertaken on the chemical reactions of pollutants in the atmosphere, and on dispersal and convective processes in the atmosphere.

An interesting feature of the report is the reference to the development of a small portable instrument, which is intended to be used in place of the Ringelmann chart. Those familiar with the Ringelmann method will recognize that it has never proved to be a really satisfactory means of assessing smoke pollution. In principle, the new instrument consists of a small telescope containing a number of translucent screens, darkened to standard shades, with which the smoke can be compared. The instrument is held so that the screens are seen against the same background as the smoke. It is easy to read, and consistent observations are obtained by different observers.

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* Department of Scientific and Industrial Research. Fuel Research 1957: Report of the Fuel Research Board with the Report of the Director of Fuel Research for 1957. Pp. iv+59+4 plates. (London: H.M. Stationery Office, 1958.) 4s. 6d. net.

Another problem which has been investigated is the emission of exhaust gases from motor-vehicles, a nuisance familiar alike to motorist and pedestrian. In this case the effectiveness of a catalytic combustion unit has been examined and found to reduce substantially the concentration of carbon monoxide in the exhaust gas. The life of the catalyst, however, as would be suspected, is a limiting factor of usefulness, signs of deterioration having been shown after 11,000 miles.

There is an impression on the lay mind, arising perhaps from the magic associated with the development of nuclear energy, that a new scientific sun has arisen which will put out the candle of coal. As yet it may be wishful thinking. Our coalfields are still of great importance to Great Britain, and this situation must yet remain for a long time. Accordingly, the reference in the report to the continuation of work on the synthesis of oil from coal should be regarded as a timely reminder of the problems ahead. With the development of nuclear energy, the rapid spread both domestically and industrially in the use of oil, and the foreshadowed increase in the application of oil to the making of towns' gas, it is not possible to envisage a future surplus of low-grade coal of the kind now consumed by power stations. The total gasification of such coal into gaseous fuels suitable for distribution or for synthetic purposes is a matter to which serious attention should be given. It will need national support on a far more substantial scale than has been applied in the past. By this means alone can the sulphur problem in atmospheric pollution be solved. The reduction in the consumption of coal may before long become a major issue in fuel policy. We are approaching the situation in which we may see even remunerative collieries shut down, while at the same time attempting to sell exports in a highly competitive market in order to pay for imported fuels that have replaced the use of coal.

This statement may well be regarded as controversial, but to envisage the possibility is to take stock of the remedy. There is accordingly no less urgency in fuel research than there was when the Fuel Research Station at Greenwich was established in 1917, for as the field of activity has extended the problems have multiplied. In this way alone does technological advancement, so much needed in a modern world, take place.

R. J. SARJANT

THE METROPOLITAN WATER BOARD

REPORT FOR 1955–56

THE Metropolitan Water Board now distributes 322 million gallons of water daily, taking its raw supplies both from rivers and wells, treating them by a wide variety of processes and carrying out very extensive chemical, bacteriological and biological research to develop new methods of treatment and control and to maintain the safety and palatability of the finished product. The reports of the Director of Water Examination always contain a detailed and well-documented account of the quality control, and research, for which he is responsible. A large part of the bacteriological section of the present report* is concerned with the enumeration of bacteria, particularly of coliforms, by the method of multiple tubes and by membrane filtration. It has been shown that the membrane filtration technique is superior for the examination of some, but not all, types of water; it is, for example, now used as the standard method for the routine examination of all stored waters. It has been found that the membranes, which are somewhat expensive, can be re-used several times, and it seems possible that the method may eventually prove to be much cheaper in materials than the multiple tube technique previously employed. Another very useful piece of work described in this part of the report deals with the standardization and selection of bile salts and peptone—different samples of which differ considerably in their properties in the MacConkey test.

The biological section of the report is concerned mainly with the control of the growth of planktonic algae in reservoirs. A constant check is made of the numbers of these at different depths and of the concentration of nutrient substances in the water, and from this information the counter-measures to be used to prevent interference with the treatment plants are decided. It is sometimes possible to avoid trouble by altering the depth at which water is drawn from a reservoir; sometimes copper sulphate is added, though this always involves a considerable risk of failure and usually requires calm weather to be successful; and it is still necessary at times to take a reservoir out of service until an outburst of algae has died down. Hydrographic studies on the King George VI reservoir, together with experiments with models made in conjunction with the University of London, have suggested that the difficulties caused by thermal stratification, which limit the allowable depth, may not be so serious as had been thought and that it might be practicable and economic to induce vertical circulation of the water by pumping or by careful design of inlets. A differential temperature recorder for varying thermal stratification has been developed and has been tested in the field.

There is a further account of research on the sterilization of jute yarn, which is used for packing joints between pipes. It is now suggested that the yarn might be sterilized by the vapour of formaldehyde, being then treated with copper sulphate, iron alum, and sodium carbonate to prevent rotting.

A long section of the report deals with comparative tests with several large experimental plants (both upward-flow and horizontal-flow) on the clarification of water after coagulation with alum and activated silica; the effect of treatment on the filterability, bacterial count, chemical composition, and numbers of invertebrates and algae, has been studied in great detail. From results of large-scale experiments it is believed that it would be economic to recover alum for re-use from the sludge by drying it, calcining and treating with sulphuric acid.

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* Metropolitan Water Board. Thirty-seventh Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the years 1955–1956. By E. Windle Taylor. Pp. 112+7 plates. (London: Metropolitan Water Board, 1958.) 21s.

The present report includes an index of the thirtieth to the thirty-seventh reports (1935–56).

B. A. SOUTHGATE

YIELD OF INFECTIVE 'RIBONUCLEIC ACID' FROM IMPURE MURRAY VALLEY ENCEPHALITIS VIRUS AFTER DIFFERENT TREATMENTS

By G. L. ADA and S. G. ANDERSON

Walter and Eliza Hall Institute of Medical Research, Melbourne

FOLLOWING the procedure of Gierer and Schramm[1], we have prepared an infective product by phenol treatment of crude suspensions of Murray Valley encephalitis virus from baby mouse brains. The infectivity of this product was destroyed by pancreatic ribonuclease (Worthington) and by normal rabbit serum, but in saline was more stable than virus. It seems that this product is essentially ribonucleic acid, although it probably contains other substances also. Following the practice of other workers[2], we have designated the product 'RNA'. For titration, virus has been diluted in 10 per cent normal rabbit serum in saline, and 'RNA' has been diluted in a phosphate citrate buffered saline at pH 7·1. Chick embryos 12 days old were inoculated on the chorioallantoic membrane with 0·05 ml. vol., and the lethal end-points were determined at 3 days.

In most respects, the 'RNA' of Murray Valley encephalitis virus behaved like the 'RNA' of other viruses recently reported. But in addition it was found possible to recover infective 'RNA' from crude virus which had been treated in various ways designed to reduce its infectivity considerably.

When crude virus with a titre of $10^{6\cdot7}$ was treated with 9 per cent phenol for 1 min., the resulting suspension had no infectivity. After subsequent treatment of this suspension with 90 per cent phenol, as in the standard method of Gierer and Schramm, infective 'RNA' appeared and reached a titre of 10^4–10^5 by the end of the extraction procedure.

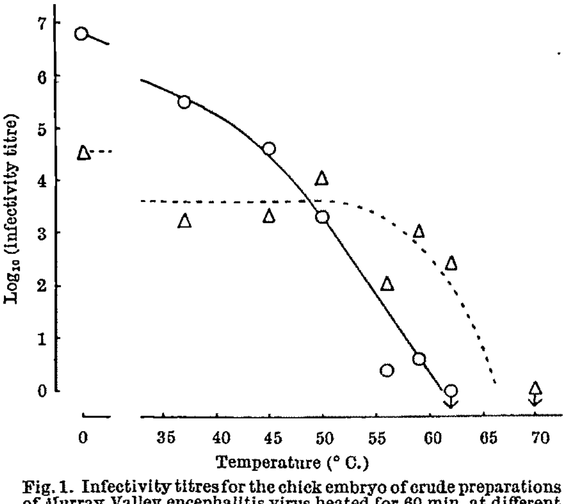

Fig. 1. Infectivity titres for the chick embryo of crude preparations of Murray Valley encephalitis virus heated for 60 min. at different temperatures and of the 'RNA' derived by phenol treatment from such heated virus
○, infectivity of heated virus; △, infectivity of ribonucleic acid derived from heated virus

Crude Murray Valley encephalitis virus lost infectivity on heating; for example, original virus with a titre of 10^7 was reduced in titre to $10^{1\cdot0}$ by holding at 56° C. and pH 7·1 for 60 min.; and after holding at 62° C. for 60 min. the undiluted preparation failed to infect chick embryos. The standard phenol procedure was applied to both these heated preparations and yielded samples of 'RNA' with infective titres of $10^{2\cdot0}$ and $10^{2\cdot7}$, respectively. These latter infectivities were lost on incubation with 1 μgm./ml. of ribonuclease for 20 min. at 15° C. A series of results of this type is shown graphically in Fig. 1. The normal ratio of titre of original crude virus to titre of 'RNA' derived from this virus was usually about 10^2 as titrated in eggs. For virus heated at or above 50° C. for 60 min. this ratio became less than 1.

Throughout the present work all titrations of infectivity were carried out in chick embryos, but it may be noted that if infectivities were titrated by inoculation of baby mice by the intracerebral route, normal virus titred at $10^{8\cdot2}$ and 'RNA' derived from it, at $10^{2\cdot8}$ $LD50$ per 0·01 ml. This V/R ratio ($10^{8\cdot2}/10^{2\cdot8}$) fell to $10^{2\cdot7}/10^{0\cdot5}$ for virus heated at 62° C.

Virus lost titre at a low pH. After standing at pH 3·0 for 30 min. at 20° C., a crude preparation of

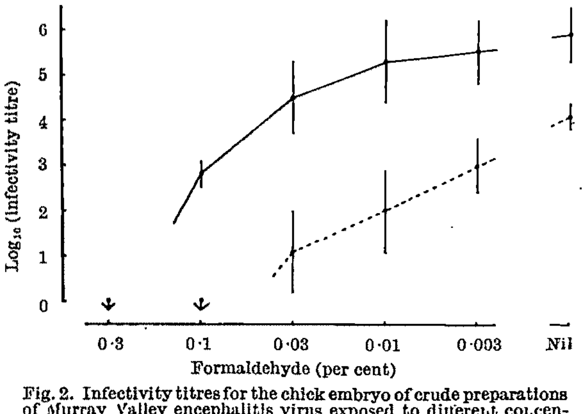

Fig. 2. Infectivity titres for the chick embryo of crude preparations of Murray Valley encephalitis virus exposed to different concentrations of formaldehyde for 195 min. at 20° C. and of the 'RNA' derived by phenol treatment from such treated virus. Each point is the mean value of between 4 and 10 experiments, the vertical lines representing the standard deviation
——, infectivity of treated virus; – – –, infectivity of ribonucleic acid derived from treated virus

virus with an original titre of $10^{6\cdot8}$ had a titre of $10^{3\cdot1}$, but on phenol treatment this then yielded 'RNA' with an infective titre of $10^{4\cdot8}$. Again, a virus preparation of original titre $10^{7\cdot0}$ had a titre of $10^{2\cdot8}$ after standing at *p*H 2; but then yielded 'RNA' with a titre of $10^{3\cdot5}$.

Attempts were made to extract infective 'RNA' from virus which had been treated with various concentrations of formaldehyde. Fig. 2 shows that concentrations of formaldehyde of 0·01 per cent or higher reduced the infective titre of a crude virus preparation over the period of 3½ hr. at 4° C. Crude virus treated with formaldehyde in the range of 0·003–0·1 per cent yielded relatively less infective 'RNA' than did control virus held at 4° C. without formaldehyde. Similar results were obtained even when the formaldehyde was neutralized with ammonia before the preparation of the 'RNA'.

Essentially the results with phenol, heat and low *p*H show that damaged crude preparations of Murray Valley encephalitis virus will yield 'RNA' with an infectivity for the chick embryo which may be greater than that of the preparation from which the 'RNA' is obtained. This does not hold for virus preparations damaged by formalin. Here the yield of infectivity in extracted 'RNA' is, on the contrary, unduly low.

Any interpretation of these findings requires a knowledge of the source of the 'RNA' within the crude virus preparation. For reasons based on experimental work to be reported elsewhere, we prefer to use as a working hypothesis the assumption that 'RNA' comes essentially from the infective virus particles. We also assume that the process of infection of cells involves as a necessary step the intracellular liberation of infective nucleic acid. On such a basis it is natural to suggest that heat, acid or dilute phenol acts by denaturing the surface protein, and that this makes intracellular biological liberation of ribonucleic acid from the infecting particle difficult or impossible but leaves much of the ribonucleic acid unaltered and capable of liberation by phenol treatment.

On the other hand, the effect of formalin would seem to be primarily on the ribonucleic acid[3] or on the mechanism of union between protein and ribonucleic acid in the particle. It appears that in this case the intracellular processes are more effective than phenol for the liberation of infective 'RNA'.

We would stress that the final interpretation of these results with crude virus must await the study of purified virus under comparable conditions.

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CHROMOSOME MAPS OF *SACCHAROMYCES*

By PROF. CARL C. LINDEGREN, GERTRUDE LINDEGREN, ERNEST E. SHULT and SHARON DESBOROUGH

Biological Research Laboratory, Southern Illinois University, Carbondale

LINDEGREN AND LINDEGREN[1,2] reported linkage between two genes controlling histidine (*HI*) and anthranilic acid (*AN*) requirements in *Saccharomyces* and the five separate 'centromere markers': (1) the mating-type locus (α/*a*), the loci of genes controlling the syntheses of (2) *para*-aminobenzoic acid, (3) uracil, (4) adenine, and (5) the fermentation of galactose—and other linkages between genes controlling nutrilite requirements for inositol, pyridoxine and thiamine. In the lumped data from a number of small families (in which other tetrad distributions were not always consistent) the centromere linkages (α, galactose (*GA*), uracil (*UR*)) and the linkage of histidine (*HI*) to anthranilic acid (*AN*) (which was afterwards confirmed by Leupold[3]) were consistently repeated. A complete map (Fig. 1) was finally constructed when a recent series of nineteen large families (each of which was heterozygous for 8–19 loci simultaneously) totalling more than 1,184 asci (involving at least 10 'new' gene markers) were analysed. Bold-face type indicates markers the order of which has been repeated consistently in every family heterozygous for these genes, in spite of variations in the frequencies of crossing-over and interference in the different families. The genes are arranged on a scale roughly proportional to the average number of cross-overs per meiosis in all the families analysed.

(The recombination values are not measured in centimorgans but as the average number of cross-overs per meiosis, estimated by assuming a Poisson distribution of crossing-over in the absence of chromatid interference. The units of measurement will be called 'stranes'[4–6]. Stranes correspond closely to centimorgans over short distances but deviate markedly, becoming greater as the distances increase. Although stranes are not subject to an upper limit of 50, they are subject to a sampling error which increases rapidly, making higher values less reliable. The considerable 'shrinkage' distortion characteristic of maps based on centimorgans is avoided by the use of stranes. The principles on which this unit is established were laid down by Sturtevant (for linearity)[4], Trow[5], Haldane[6], Mather and Beale[7], Rizet and Engelmann[8], but the defence of the concept of interference by Sturtevant[4] and Muller[9] and later by Weinstein[10] discouraged American geneticists for many decades from exploiting methods for correcting recombination values. The view that such correction is possible has been recently revived by Papazian[11], Spiegelman[12] and Shult and Lindegren[13], and the results from tetrad analysis presented here appear to justify this view. The additivity of stranes (as shown by the complete results which will be presented in detail elsewhere) even at high values is much more precise than would be expected on the older views.)

Loci, the linkages of which appeared significant in only a few families, are written in light-face type to denote a lower level of certainty. The phenotypes of the gene symbols are indicated in Table 1.

MA controls the synthesis of maltase, which splits maltose and turanose but no other sugars, *MZ*

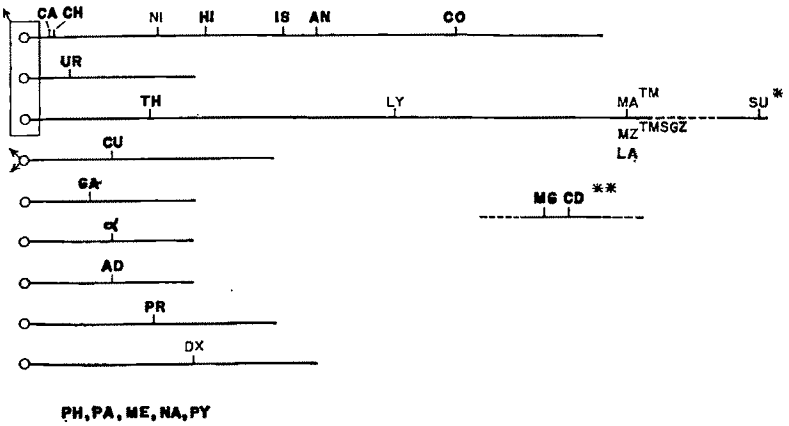

Fig. 1. Chromosome maps of *Saccharomyces cerevisiae*. Circles denote centromeres with the respective chromosome arms to the right. The box enclosing the first three centromeres indicates their preferential segregation to the same pole. The arrows on the *CU*-centromere indicate respective instances of 'coupling' and 'repulsion' of this centromere with those enclosed in the box. Gene symbols are defined in Table 1. Genes listed at the bottom of the map have not shown consistent linkages with other genes in these families; genes in light-face type show consistent linkage but appear in only a few families; genes listed in bold-face type have shown linkages consistent with the map arrangement in every family heterozygous for the genes

* The location of *SU* distal to the *MA* allele is strongly suggested by earlier data of Lindegren and Lindegren (ref. 24). ** This linkage group was established by Middlekauff, Hino, Yang, Lindegren and Lindegren (ref. 25) and Lindegren and Lindegren (ref. 26), but has not as yet been located

controls the synthesis of melezitase, which splits maltose, turanose, sucrose, methyl-α-D-glucopyranoside and melezitose together with a few other short-chained α-glucosides. The enzymes produced by *MA* and *MZ* are different since the maltase produced by *MA* will not split methyl-α-D-glucopyranoside, melezitose or sucrose. *LA* controls the splitting of lactose and is inferred from Kluyver's[14] rule that the fermentation of lactose in *Saccharomyces* excludes the fermentation of maltose and vice versa, which is the operational definition of an allele. A multiple series of alleles exist at the *MZ* locus, all controlling the synthesis of the same enzyme, melezitase, but differing from one another by the inductors to which they respond to effect the synthesis of the enzyme. It is suggested that the three major alleles are either very closely linked or are multiple alleles occupying a single locus.

Winge and Roberts[15], Gilliland[16], Hawthorne[17] and Douglas and Condie[18] have described isomeric genes controlling the synthesis of enzymes splitting carbohydrates or converting galactose into fermentable hexose. But the term 'isomeric' requires more specific definition. For example, there are three different genes in *Saccharomyces* which control different enzymes that split maltose; *MA*, *MZ* and *DX*. If 'isomeric' means genes which achieve the same result, then these genes are isomeric; if it means genes which are duplicates of each other at different locations 'isomeric' is a misnomer. A series of different (so-called 'isomeric') genes which are said to control the fermentation of galactose actually act only to change the rate at which a single primary gene produces its enzyme. According to the established conventional procedure, these genes are plus or minus modifiers of the primary gene *GA*, which is the only gene in *Saccharomyces* that has been demonstrated to respond to galactose by the production of an enzyme or an enzyme system which converts galactose into fermentable hexose.

Table 1

Symbol	Phenotype
α/a	Mating type
AD-1	Adenine requirement
AN	Anthranilic acid requirement (replaced by tryptophan)
CA	Resistance to 0·2–0·4 per cent caffeine
CH	Choline requirement
CO	Resistance to 1·0–2·5 per cent cobalt
CU	Resistance to (1–2) × 10^{-3} *M* copper
CD	Resistance to 0·01–0·02 per cent cadmium
DX	Fermentation of dextrin
GA	Fermentation of galactose
HI	Histidine requirement
IS	*iso*Leucine requirement
LY	Lysine requirement
ME	Fermentation of melibiose
NI	Resistance to 1–10 per cent nicotine
PR	Proline requirement (replaced by arginine)
TH	Thiamine requirement
MA	Fermentation of maltose
MZ	Fermentation of melezitose
LA	Fermentation of lactose

The genes for the nutrilite requirements nicotinic acid (*NA*), phenylalanine (*PH*), pyridoxine (*PY*) and pantothenic acid (*PA*) and a gene for the fermentation of melibiose (*ME*) (although regularly Mendelian) have to date shown no consistent linkage to any other genes. Introduction of 'new' genes may be expected to bring these 'unlinked' genes into the map.

Chromosome I, which has been well established by the analysis of numerous hybrids, comprises the additive linear sequence *CA*, *CH*, *HI*, *IS*, *AN*, *CO*. In each of 6 families (452 tetrads, Table 2) heterozygous for the markers *UR*, *TH*, *CH* (or *CA*) and any combination of the markers *HI*, *IS*, *AN* and *CO*, it was found that linkage group 1 'branched' into two arms carrying *UR* and *TH*, respectively. The tetrad distributions of the three centromere markers (*CH*, *UR* and *TH*) with other randomly segregating centromere markers (α and *GA*, Table 3) show that the point of 'branching' is identical with the centromere of Chromosome I, about 5 units from the tightly linked genes *CA* and *CH*. The marker *CU* constitutes a fourth directly linked branch (in 2 of the 6 families; 132 tetrads, Table 3), but reverse linkage (74 per cent recombination) of *CU* with *CH* (and other members of its linkage group) in one family of 180 tetrads,

Table 2. THE TOTAL NUMBER OF REGULARLY SEGREGATING TETRADS INVOLVING THE THREE CHROMOSOMES IDENTIFIED RESPECTIVELY BY THEIR CENTROMERE MARKERS: *UR*, *TH* AND *CH*

	Gene marker								
	UR	*TH*	*CH*	*IS*	*HI*	*AN*	*CA*	*CO*	*NI*
Family No:									
108	180	180	180	180	180	180			
107	50	50	50	50	50	50			
99	30	30	30	30	30	30			
97	30	30	30	30	30				
96	60	60	60	60	60				
106	96			96	96	96			
111	102	102	102				102	102	
93	101			101	101				
88	20			20	20	20			
89	75			75					
116	162		162		162		162	162	
117	20	20	20				20		
110		38	38						
81					51	51		51	
85					33	33			
113		22	22	22			22		22
112		30	30	30			30		
98		20	20	20					
109		64	64	64					
Total tetrads	926	646	808	772	813	460	336	315	22

Table 3. THE TOTAL NUMBER OF REGULARLY SEGREGATING TETRADS INVOLVING THE VARIOUS CENTROMERE MARKERS

	Gene markers								
	a	*GA*	*CU*	*UR*	*TH*	*CH*	*CA*	*AD*	*PR*
Family No.:									
108	180	180	180	180	180	180			180
107	50			50	50	50			
106	96		96	96				96	
99	30		30	30	30	30			
97	30			30	30	30		30	30
96	60			60	60	60		60	60
111	102	102	102	102	102	102	102	102	102
93	101	101		101				101	
88	20	20		20				20	20
89	75	75		75				75	
116	162	162		162	162	162	162		162
117	20	20		20	20	20	20	20	20
110	38	38			38	38		38	
81	51								51
85	33	33						33	33
113	22				22	22	22		
112	30				30	30	30		
98	20		20		20	20			
109	64	64			64	64		64	64
Total tetrads	1,184	795	428	926	808	808	336	639	722

established unequivocally that *CU* was located on a chromosome separate from *CH* and, in this case also, the point of 'branching' is identical with the centromere of Chromosome I. These results prove that the apparent branching of linkage groups results from preferential segregation of centromeres in parental combination and that reverse linkage results from preferential segregation of centromeres in non-parental combinations, a situation identical with that reported by Wallace[19] except that (1) the preference is nearly 100 per cent instead of 67 per cent and (2) the added advantage of tetrad analysis enables one to locate the centromere with precision[20,21]. These findings provide the first confirmation of the hypothesis[19,22] that the site of 'affinity' is the centromere.

It has not yet been possible to separate the 'branches' *UR*, *TH* and Chromosome I into two or three chromosomes, and, for this reason, they are represented tentatively as three separate chromosome arms preferentially segregating to the same pole, with the reservation that two of the arms may be opposite arms of the same chromosome. From the linkage results, it is inferred that the haploid number of chromosomes in *Saccharomyces* is at least seven. This disparity with the finding of McClary, Williams, Lindegren and Ogur[23] reflects the difficulties inherent in the cytological analysis of micro-organisms, especially when the problem of size is further complicated by the synapsis of non-homologous centromeres.

This work has been supported by research grants from the American Cancer Society *E*-125 and the U.S. Public Health Service *C*-2140.

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DIFFERENTIAL DISTRIBUTION OF RADIOACTIVE STRONTIUM AND YTTRIUM IN THE TISSUES OF THE RABBIT'S EYE

By R. H. MOLE
Medical Research Council Radiobiological Research Unit, Harwell

ANTOINETTE PIRIE
Nuffield Laboratory of Ophthalmology, University of Oxford

AND

JANET M. VAUGHAN
Medical Research Council Group for Research on Bone-seeking Isotopes, Churchill Hospital, Oxford

THE maximum permissible level of body burden for each radioactive material depends on knowledge of (or assumptions about) the tissue in which the material is chiefly concentrated. Retention has been investigated experimentally in the major tissues of the body[1], such as bone, bone marrow, muscle, liver, but specialized organs of proportionately small bulk have hitherto been ignored except in the case of the thyroid gland. When the toxicity of radioiodine was first considered, the thyroid was not overlooked because its ability to concentrate iodine was already well known. Fission products, however, consists largely of elements about which little is known physiologically, and not much consideration seems to have been given so far to the possibility that radioactive materials other than radioiodine might be concentrated in specialized organs, to such an extent as to be of importance in determining their maximum permissible level. Biological concentration due to specialized metabolic processes is the major unknown in assessing the hazards of radioactive isotopes of trace elements, that is, of fission products.

Table 1. Concentration of Strontium-90 (mean ± *S.E.*) in Components of the Rabbit's Eye as Fractions × 10^4 of the Concentration in the Femur of the same Animal (Equilibrium Values)

Time since injection of strontium-90	7–8 hr.	1 day	3 days	9 days	30 days
No. of animals	3	5	3	4–5	7.
Iris with ciliary body	110 ± 20	83 ± 4	69 ± 6	51 ± 5	42 ± 5
Choroid	130 ± 30	82 ± 8	56 ± 0·4	29 ± 5	22 ± 3
Retina	57 ± 12	39 ± 5	25 ± 6	12 ± 2	5·3 ± 0·9
Cornea	140 ± 30	50 ± 3	24 ± 3	10 ± 1	7 ± 1
Sclera	120 ± 20	48 ± 2	24 ± 4	11 ± 1	7·6 ± 1·2
Vitreous	81 ± 13	44 ± 4	14 ± 2	4·5 ± 0·3	3·1 ± 0·4
Lens	10 ± 2	5 ± 0·3	1 ± 0·3	0·8 ± 0·1	0·5 ± 0·1
Striated muscle	36 ± 6	12 ± 1	5·6 ± 0·9	2·7 ± 0·3	2·4 ± 0·6
Femur (μc./gm. divided by μc. injected/gm. body-weight)	14·0 ± 1·2	10·3 ± 2·0	10·1 ± 1·5	6·3 ± 1·1	3·5 ± 0·3*

* Excluding No. 1012, which died (see Table 2) and had a femur value of 13.

In different species of mammal, physiologically remarkable concentrations of elements such as zinc, barium or strontium may be found in the eye[2], which suggests that their radioactive isotopes will also be concentrated there. This deduction is confirmed by the observations on strontium-90 reported here. The toxicological significance of the results depends not only on the relative radiosensitivities of bone and of such components of the eye as iris, choroid and retina, but also on the marked differences between species in the way in which many elements are concentrated in these parts of the eye.

Several fission products of the first importance from the point of view of hazards to health consist of pairs of radioactive materials, for example, strontium-90 – yttrium-90, barium-140 – lanthanum-140, cerium-144 – praseodymium-144. In each of these cases the radioactive daughter has a half-life much shorter than that of the parent element, and in most toxicological studies the equilibrium values in tissue are all that is determined. The observations reported here, however, show that, in the case of strontium-90 – yttrium-90 in the retina, ignoring the metabolic disequilibrium of radioactive parent and radioactive daughter may lead to an under-estimate of the hazard, possibly by as much as an order of magnitude.

Weanling rabbits aged 6–8 weeks were injected intravenously (J. V.) with an equilibrium mixture of strontium-90 and yttrium-90 or with yttrium-91 in doses of between 72 and 600 μc./kgm. body-weight, and killed at various intervals of time thereafter. The rabbits were maintained throughout on a standard regime[3]. Some animals were given a daily dose of strontium-90 by mouth as described elsewhere[4]. The solutions of strontium-90 – yttrium-90 and of yttrium-91 given to the rabbits were each contaminated to less than 1 per cent by other radioactive materials.

The eyes were removed when the animal was killed and transferred to a separate laboratory for dissection into their various parts, each of which was weighed (A. P.). Some eyes were dissected unfixed, some after fixation in alcohol. In the rabbit, the iris and ciliary body cannot be separated. In most cases the parts from the two eyes were combined to make one specimen. The specimens were then transferred to a third laboratory where they were dissolved in nitric acid; the solutions were made up to 10 ml. or multiples thereof, and the count-rate (hereafter abbreviated to count) determined in a Veall-type *M6H* counter (R. H. M.). Appropriate corrections were made for background and lost counts and, when many repeat counts were made, for transfer losses. The geographical separation of the laboratories was an advantage in minimizing possible contamination of specimens, most of which weighed between 10^{-4} and 10^{-5} of the body-weight.

In order to determine the strontium-90 content, at least two counts were made of each specimen, not less than a week apart, the first of these being not less than 3 weeks after dissolving the tissues in acid. After 3 weeks, yttrium-90 (half-life 64 hr.) and strontium-90 (half-life 28 years) are effectively in radioactive equilibrium. Counts of a standard solution of known concentration were made each time a series of specimens was counted so that the observed counts could be converted to microcuries and the tissue concentrations of strontium-90 or of yttrium-90 determined in μc./gm.

Many specimens were counted on one or more occasions before radioactive equilibrium had been reached. A quantitative assessment of the excess or deficiency of yttrium-90 was made by subtracting the final equilibrium counts from the earlier counts and plotting the differences on semi-logarithmic graph paper[5]. The rate of decay or growth of counts was within ± 10 per cent of that expected for yttrium-90 in all but three specimens, and in two of these was not far outside these limits. The counts from the third were discarded. The initial count which would have been expected if the tissue had been counted simultaneously with the death of the animal was determined by extrapolation, using the theoretical half-life for yttrium-90. Since the counters used were sensitive to yttrium-90 (efficiency 10–11 per cent) and insensitive to strontium-90 (efficiency 0·5 per cent), the observed counts were practically all due to yttrium-90. Thus the ratio of the initial count to the final equilibrium count gave the yttrium-90 at the moment of death as a fraction of the yttrium-90 at equilibrium. Since at radioactive equilibrium 1 μc. of yttrium-90 is equivalent to 1 μc. of strontium-90, this ratio is also equal to the ratio of μc. of yttrium-90 to μc. of strontium-90 in a tissue at the moment of death.

When the interval between death of the animal and the first count was long, or when only one pre-equilibrium count was available (Table 2), the identity of yttrium-90 could not be proved, and the accuracy of determination of the expected initial count was low. Also, the closer the first count to the final equilibrium count the less accurate the determination of their difference, so that the exact value of the yttrium-90/strontium-90 ratios near 100 per cent must be uncertain, although the fact that equilibrium was nearly complete is, of course, sure.

The equilibrium concentration of strontium-90 in different tissues, expressed as a fraction of the injected dose per unit body-weight at different times after a single injection, is shown in Fig. 1. The scatter of the

Table 2. μc. Yttrium-90 at Time of Death as per cent of μc. Strontium-90

(1) *Injected intravenously*

No. of rabbit	Dose (μc./kgm.)	Time since administration of strontium-90	Iris with ciliary body	Retina	Choroid	Cornea	Sclera	Vitreous	Lens	Muscle	Interval between death and first count (hr.)	No. of pre-equilibrium counts per specimen
991	600	7 hr.	38	38	46	6	96	1	11	38	3	+*
950	300	8 hr.	29	—	—	14	630	—	—	130	70	1
993	100		90	54	81	4	300	−2	29	84	23	+
989	600	24 hr.	48	140	66	15	—	19	30	84	4	+
996	138		75	160	94	18	350	17	54	160	8	+
999	100	3 days	80	300	140	30	390	34	170	320	2	+
948	300	9 days	120	—	—	33	450	—	100	150	50	1
997	138		100	350	150	15	270	21	100	140	4	+
998	138	30 days	100	360	130	26	100	21	(120)†	56	3	2
1012	600		90	250	100	5	55	18	120	80	12‡	3
1022	72		100	360	100	0	100	13	(60)	44	4	2
1050	72		120	330	110	−12	110	29	(40)	56	2	2
1051	72		100	250	100	25	120	20	(40)	55	6	2
Mean for 30 days			100	310	110	9	100	20	(80)	60		

(2) *Continuous oral administration*

No. of rabbit	Total retention (μc.)	Duration of feeding (days)	Age at start of feeding	Iris with ciliary body	Retina	Choroid	Cornea	Sclera	Vitreous	Lens	Muscle	Interval between death and first count (hr.)	No. of pre-equilibrium counts per specimen
994	215	52	6 weeks	90	270	95	13	100	−8	100	80	96	2
921	8·1	162	1 year	130	990	250	35	180	50	80	190	50	1
930	217	224	7½ weeks	100	910	120	−7	170	19	95	120	52	2
918	3,715	431	2 years	110	1,000	110	100§	130	29	100	100	2	3
Mean after oral administration				110	800	140	?	150	20	90	120		

* + signifies 4–8 pre-equilibrium counts.
† The values in parenthesis are very uncertain because the count-rates in the specimens amounted to only a small fraction of the background.
‡ This animal died during the night and this time is uncertain by ± 8 hr.
§ The strontium-90 content of this cornea was exceptionally high (? contaminated, ? correlated with age of animal).

results is reduced if the tissue concentration is expressed as a fraction of the concentration in the whole femur of the same animal (Table 1).

Different parts of the eye differed several-fold in their uptake and retention of strontium-90. The pigmented parts of the eye, iris with ciliary body and choroid, showed the highest concentration at all times after the first hour. Cornea and sclera came next, followed by retina and then vitreous. As might have been expected the concentration in the lens was least of all, from one-fifth to one-tenth of that in the vitreous. The concentration in striated muscle, a representative soft tissue, was intermediate between vitreous and lens.

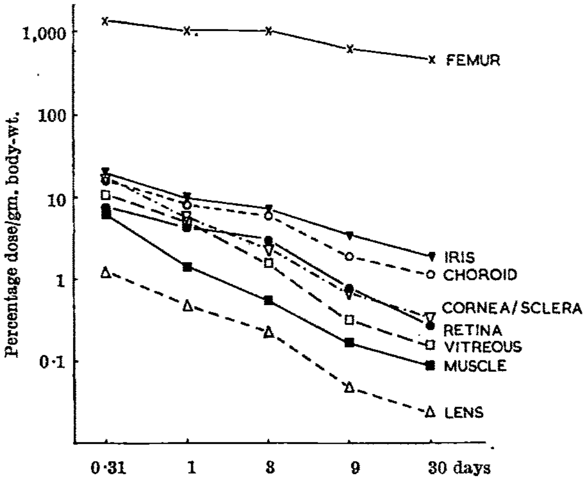

Fig. 1. Strontium-90 in bone and in the tissues of the eye of the rabbit
Abscissa, time in days after single intravenous injection; ordinate, strontium-90 in μc./gm. of tissue expressed as percentage of μc. injected/gm. body-weight. Both scales logarithmic
The values for cornea and sclera are so similar that they have been plotted as one

There was a 10–50-fold drop in concentration of radiostrontium in the different parts of the eye 7–8 hr. to 30 days after injection. Although between 9 and 30 days the absolute levels decreased by about a half (Fig. 1), their ratio to the concentration in the femur changed much less (Table 1). After the initial phases of redistribution, therefore, the strontium-90 was as fixed, or as mobile, depending on the point of view, in the soft tissues of the eye as in the bone.

The concentration of stable strontium has been determined in the different parts of the rabbit's eye, dissected in the same way[3]. The relative proportions of radiostrontium in the different tissues at 9–30 days were similar to their relative content of stable strontium, though with a wider range in values than for stable strontium.

In two rabbits at 3 months and one at 6 months after injection a broadly similar pattern for the concentration of strontium-90 was found. The discrepancies observed may possibly be due to the fact that the counting-levels at these time-intervals were low and the results consequently uncertain.

Table 2 gives the results on the equilibrium between yttrium-90 and strontium-90 at the time of death as deduced by the method described. All parts of the eye showed an increase in the ratio of μc. yttrium-90 to μc. strontium-90 during the first three days after injection. The cornea and vitreous showed a marked deficiency in yttrium-90 at all times but by three days after injection choroid, retina, sclera and muscle contained a definite or marked excess of yttrium-90. A persistent excess was found only in the retina.

When strontium-90 with yttrium-90 in equilibrium was fed daily the order of activity concentration in the different parts of the eye was the same as 1–30 days after a single injection. The cornea and vitreous were again relatively deficient in yttrium-90 (Table 2), the lens and iris were nearly in equilibrium, while the choroid and sclera showed a definite excess of yttrium-90. This excess, however, was most

Table 3. CONCENTRATION OF YTTRIUM-91 IN COMPONENTS OF THE RABBIT'S EYE 11 DAYS AFTER ADMINISTRATION (μC./GM. TISSUE AS PERCENTAGE OF μC. INJECTED/GM. BODY-WEIGHT) AND COMPARISON OF YTTRIUM-91 WITH STRONTIUM-90 AND YTTRIUM-90

	Concentration of yttrium-91 at 11 days			11-day values in rabbits given strontium-90 + yttrium-90		
	Rabbit No.				Yttrium-90	
	986 (killed)	987 (died)	Mean	Strontium-90 (estimated from results of Fig. 1)	(derived from strontium-90 values together with results of Table 2)	(contribution expected from yttrium-90 injected*)
Iris with ciliary body	5·2	17·6	11	3	3	1
Choroid	12	32	22	2	2	1
Retina	0·59	0·49	0·5	0·7	2	very small
Sclera	15	15	15	0·7	2	1
Vitreous	0·01	0·036	0·02	0·3	0·06	very small
Lens	0·035	0·076	0·05	0·04	0·04	very small
Cornea	0·06	0·45	0·3	0·7	0·2	very small
Muscle	6·7	4·1	5·4	0·16	0·2	0·3

* Assumed to be one-sixteenth of mean yttrium-91 value because the injected yttrium-90 would have decayed to one-sixteenth of its original level after 11 days (see text).

pronounced in the retina, where μc. yttrium-90 per gm. averaged eight times the equilibrium value.

Two rabbits were given single injections of yttrium-91 and were examined 11 days later. The tissue concentrations of yttrium-91 were the same as those of strontium-90 in the retina, lens and cornea, but four times higher in the iris and 20–40 times higher in choroid, sclera and striated muscle (Table 3). The vitreous was the only tissue with less yttrium-91 than strontium-90. Thus the difference in retention between different parts of the eye was greater for yttrium-91 than for strontium-90. The difference in concentration of yttrium-91 between retina and choroid is especially noteworthy: it is impossible to make an absolute separation between them when dissecting the eye, and the relatively small amount of yttrium-91 in the retinal specimens may well have been wholly derived from adherent fragments of choroid.

In studying the results it must be understood that the yttrium-90 formed by the radioactive decay of strontium-90 cannot be expected to behave chemically or physiologically in the same way as radiostrontium. Strontium is one of the divalent alkaline-earth metals. Yttrium is trivalent and behaves like the rare earths. The two elements form compounds of different solubilities which may well influence their rates of diffusion, and their physiological behaviour is also different. Both elements are concentrated in bone, though in different sites[6], but yttrium, unlike strontium, may also be retained in soft tissues, particularly the liver, stomach and spleen[7]. A similar preferential uptake of injected yttrium-91 as compared with injected strontium-90 was found in sclera, choroid and iris with ciliary body (Table 3).

The slower diffusion of yttrium as compared with strontium is clearly shown by the deficiency of yttrium-90 in the avascular tissues, cornea, vitreous and lens, as compared with the other parts of the eye during the first 24 hr. after injection of an equilibrium mixture of yttrium-90 and strontium-90 (Table 2). Without knowledge of the relative blood levels of radiostrontium and radioyttrium it is not possible to decide whether there is any difference in the rate of penetration into the other parts of the eye.

The relative excess of yttrium-90 from 1 to 9 days after injection in all the other parts of the eye is perhaps most simply explained by the combined effect of two factors: (1) the fact that the concentration of radiostrontium in the tissues fell during this time interval, (2) the assumption that yttrium is not easily lost from a tissue once it is deposited there, as evidenced by the very high concentration of yttrium-91 as long as 11 days after its injection (Table 3). It is known also in the case of bone that, though retention of yttrium-91 may be of the same order as that of strontium-90 up to 7 days after injection[6], over a period of 6 months the loss of yttrium-91 is less[8]. A fall in the concentration of strontium-90 in a tissue due to outward diffusion from the cells must lead to a relative excess of yttrium-90 if the yttrium cannot diffuse outwards so easily. The rate of change of the level of strontium-90 in tissue decreased with time after injection and correspondingly the excess of yttrium-90 should have decreased progressively from 3 to 30 days, as was seen in sclera, choroid, cornea and muscle (Table 2). When the rate of change of concentration of strontium in tissue is slow compared to the rate of decay of yttrium-90, as at 30 days after injection, a difference in the rate of diffusion between strontium and yttrium would not be detected in this way.

The values for yttrium-90 at the earlier time-intervals will certainly not depend wholly upon yttrium-90 generated from strontium-90 within the body of the rabbit. The injected solution was an equilibrium mixture of strontium-90 and yttrium-90 so that the rabbits given strontium-90 were also injected with yttrium-90. This injected yttrium-90 would be expected to distribute itself just like the yttrium-91 since both isotopes were in the same chemical form when injected. A comparison may be made at 11 days after injection (Table 3) when the activity of injected yttrium-90 will have decayed to one-sixteenth of its original level (eleven days equal four half-lives of yttrium-90). At this time the contribution of injected yttrium-90 to the values observed for that radioisotope will be one-sixteenth of the mean values for yttrium-91 when tissue concentrations are expressed in the same units (fractions of injected dose per unit body-weight). The results in Table 3 show that direct uptake of yttrium-90 injected would contribute significantly to the observed levels of yttrium-90 11 days after injection in muscle, sclera, choroid and iris with ciliary body but not in retina, cornea, vitreous and lens. Some or all of the relative excess of yttrium-90 over strontium-90 in muscle, sclera and choroid at 3–9 days after injection (Table 2) may therefore be due to direct uptake of injected yttrium-90. At 30 days there was no excess of yttrium-90 in these tissues but by 30 days the radioisotope injected would have decayed by eleven half-lives and so would not contribute measurably to the amount observed in the tissue.

None of the factors already considered can account for the excess of yttrium-90 in the retina 30 days after injection of strontium-90; this excess can only come from yttrium-90 liberated from or generated within the tissues. The results in the retina at earlier times were also exceptional. There was a large excess of yttrium-90 at 3–9 days, even though the direct uptake of yttrium-91 was low at 11 days, and this excess changed relatively little with increase in time after injection of strontium-90 from 3 to 30 days. A similar excess of yttrium-90 was not found in the grey or white matter of the central nervous system. If yttrium cannot diffuse into or out of the retina, then the maximum possible amount of yttrium-90 in the retina at a constant blood level of strontium-90 is the equilibrium amount, whatever the rate at which strontium can diffuse into and out of the retinal cells. The yttrium-90 observed 30 days after injection, when the blood level must have been very stable, was certainly greater than this (Table 2). The excess of yttrium-90 was still larger in animals fed daily on strontium-90.

There is the possibility that the retina in animals given strontium-90 did not behave in the same way as in animals given yttrium-91, that is, in one set of animals radiation damage altered the ability of the retina to accumulate yttrium directly. The dosage of yttrium-91 was a little greater than that of strontium-90, it is true, but no difference was noted over a several-fold range in dosage of strontium-90 (Table 2). Thus, if there was radiation damage to the retina, it was in the animals given yttrium-91, and this does not affect the conclusion from the results of Table 2, namely, that the equilibrium count in a tissue containing radioactive parent and daughter isotopes may markedly under-estimate the radiation dose received by that tissue.

The yttrium-90 in the retina in excess of the equilibrium value must therefore originate in yttrium-90 liberated from other tissues laden with strontium-90 or yttrium-90, and there must be something in the retina which is capable of binding this yttrium-90 when it reaches the retina. Injected yttrium-91, however, was not bound by the retina even though it must have reached the eye, as was shown by its high concentration in choroid, iris and sclera. Presumably the chemical form and hence biological behaviour of yttrium liberated continuously from strontium-90 within the body is not necessarily the same as in the solutions of yttrium-91 or strontium-90 plus yttrium-90 used for injection. The retina thus behaves like many other soft tissues where the direct uptake of yttrium varies markedly with the chemical form in which the yttrium is administered[7]. It will be of interest to identify the chemical form in which yttrium-90 is liberated from tissues into the bloodstream, and which is selectively taken up by the retina but apparently not by the other tissues of the eye.

From 1 day after injection and thereafter the concentration of strontium-90 in the iris with ciliary body, the most radioactive part of the rabbit's eye, was always less than 1 per cent of the concentration in bone in the same rabbit. If it is considered that the harmful effects of radiation are due to its direct action on irradiated cells, the bone would have to consist of less than 1 per cent cells before a given mass of iris would have as great a chance of being damaged as the same mass of bone. Other factors needing consideration are the difference in bulk of bone and eye (if the harmful effect is due to the probability of change in any cell in the organ), the intrinsic radiosensitivity of bone and iris, and for particles as energetic as the β-particles of strontium-90 and especially yttrium-90, the geometrical distribution of dose in a complex organ like the eye where thin layers of tissue concentrate radioactivity to differing degrees. Clearly, existing information on all these points is too slight for any useful theoretical comparison of the eye and the bone as 'critical tissues' for strontium-90. No clinical observations of damage to the eye seem to have been made in experimental animals after administration of strontium-90 in doses sufficient to cause bone tumours.

The experimental result which may have important toxicological implications is the large excess of yttrium-90 in the retina of rabbits given strontium-90, especially after chronic administration. This accumulation of yttrium-90 would not have been predicted from the experiments made with yttrium alone; on the contrary, it would have been denied (Table 3). In principle, therefore, whatever the explanation of the findings may be, similar unexpected accumulations of radioactive daughter products may occur whenever cells are permeable to a radioactive parent element, and may not be detected unless special search for the excess of daughter is made. In the eye it is relatively easy to separate physiologically different parts and to show how differently they behave in this respect. In a geometrically complicated organ, like bone, it has not yet been possible to separate the physiologically different components and examine them separately for excess or deficiency of yttrium-90, and no method of specimen preparation which is long compared with the half-life of yttrium-90 can hope to be successful.

In addition to the strontium-90 – yttrium-90 decay chain, other decay chains which need consideration are barium-140 – lanthanum-140, cerium-144 – praseodymium-144, tellurium-132 – iodine-132 and the natural radium, thorium and uranium series. Tellurium – iodine has been carefully considered (G. E. Harrison, personal communication, 1957), but no information is available about possible disequilibrium between barium and lanthanum or cerium and praseodymium. Each natural radioactive series is composed of a number of different chemical elements, and there is clearly a possibility that unexpected concentrations of short-lived intermediate products may occur in some tissues. The physical dimensions of a specialized organ in which an α-emitter is concentrated are likely to be of little importance in determining the tissue dose, at least as compared with energetic β-emitters.

It is interesting that both the iris and choroid of dogs given radium or mesothorium or radiothorium show pathological changes. Plutonium is less effective. The iris becomes depigmented and there is a loss of iridescence in the fundus of the eye due to changes in the tapetum lucidum with development of an albuminuric choroiditis in some dogs[9]. The concentration of radium retained in the eye is more than thirty times that in plasma and most of this is in the eye tissues rather than in the fluids[10]. These elements may be concentrated in the dog choroid in some analogous way to zinc, the concentration of which in this tissue is 8·8 mgm./gm. dry-weight[11]. The iris of dogs receiving strontium-90 daily for many months may also lose its pigment[12].

Animal experiments may give invaluable evidence about the metabolic pathways of toxic materials; but they cannot give quantitative information about tissue retention in man. It has often been supposed that if the relative concentrations of the stable isotopes of different elements in human tissues were determined, the results would give quantitative information about the relative concentrations to be expected in different tissues if men were chronically exposed to radioactive isotopes of the same elements. Perhaps because such a principle seems self-evident, no experimental verification seems ever to have been attempted. Some observational support for the principle may be found in the general similarity between the relative concentrations in different parts of the rabbit's eye of strontium-90 as reported here, and of stable strontium as found by Sowden and Pirie[2]. The concentration of stable strontium in human bone is known[13], and if its concentration in rabbit bone is similar, as the concentration in the eyes of the two species is[2], the results reported here may be directly applicable to men.

Summarizing: (1) All parts of the rabbit's eye, except the lens, accumulated strontium-90 to a greater degree than striated muscle, a representative soft tissue. The pigmented parts accumulated most, the iris with ciliary body having 0·5 per cent of the concentration in the femur at 9–30 days when redistribution was approaching completion.

(2) There were much bigger differences between physiologically different parts of the eye in their retention of yttrium-91 than in their retention of strontium-90.

(3) Yttrium-90 and strontium-90 were rarely in equilibrium in any part of the eye at any time after administration of an equilibrium mixture. The retina maintained the largest excess of yttrium-90, especially after daily administration of strontium-90, although its direct uptake of yttrium-91 was small. This difference may be due to a difference in chemical form between the yttrium-91 injected and the yttrium-90 liberated within the body.

(4) Unexpected accumulations of radioactive isotopes of trace elements may be found in specialized organs of small bulk. These may then need consideration in setting maximum permissible levels.

Thanks are due to Mr. T. E. F. Carr for standardizing a solution of strontium-90, to Mr. R. H. Watts for technical assistance, and to Miss E. Flynn, Mr. G. Herring and Mrs. E. Ramsden for helpful discussions.

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A CHEMICAL BASIS FOR THE CLASSIFICATION OF GLUME COLOUR IN NIGERIAN CULTIVATED SORGHUMS

By W. R. STANTON, T. B. MILLER and D. L. CURTIS

Regional Research Station, Ministry of Agriculture, Samaru,
Zaria, Nigeria

IN Nigerian sorghums the phenotypic expression of glume colour ranges from black through shades of mahogany and red to straw. An objective description of these colours would be of value in the classification of sorghum types[1], and accordingly a preliminary investigation of the chemistry of these pigments has been undertaken.

The material was obtained from a sample survey carried out in Northern Nigeria during 1957–58. Most sorghums mature after the rains, in November and December, and samples were collected during the dry season when the aerial relative humidity values rarely exceed 40 per cent and are often very much lower. Although it is known that grain and glume colours do fade over long periods, no changes were observed in the material received early, and it is unlikely that samples received later had altered since their collection.

Milled samples of the dried glume tissue were extracted with 0·1 *N* hydrochloric acid and examined according to the scheme of Robinson and Robinson[2] for the identification of flavonoid pigments. On extraction with amyl alcohol the pigments passed into the organic phase. Hydrolysis with 12 *N* hydrochloric acid did not alter the partition between amyl alcohol and water.

One-dimensional paper chromatograms were run on ethanol extracts obtained after 4-hr. extraction in a Soxhlet apparatus. The chromatograms were developed by the descending technique using butanol/acetic acid/water (4 : 1 : 5). Attempts to purify the extract with ethyl acetate failed to improve the development and tended to alter the relative intensities of the spots.

Fig. 1 illustrates the type of chromatogram produced. Up to three discrete spots occur with the following R_F values: spot 1, 0·76–0·80 blue-purple; spot 2, 0·89–0·93 red; spot 3, 0·95–0·99 brown.

All samples, other than 'straw' and 'white', so far examined gave spots 1, 2 and 3 or 2 and 3. No spots were visible with R_F values below 0·76 in the visible or in ultra-violet light. Treatment with ammonia intensified all spots and examination under ultraviolet did not assist differentiation appreciably.

As control pigments, extracts of fresh petals from *Pelargonium zonale* Ait. and *Petunia hybrida* Vilm. (purple) were used. The pelargonidin and petunidin spots showed R_F values corresponding to those reported by Geissman[3]. Extracts from pigmented glumes of millet (*Pennisetum typhoides* Stapf. and Hubbard) produced a blue spot of R_F 0·52. Extracts of this pigment with 0·1 *N* hydrochloric acid showed

Table 1

Sample No.	Variety name	Agronomic group	Glume colour	Spot 1, *RF* 0·76–0·80	Spot 2, *RF* 0·89–0·95	Spot 3, *RF* 0·95–0·99
NG 119	Bakin Jeje	Drummondii	Black	+++	++	Trace
PL 14	Galai	1*A* Guineensia	Black	++	Trace	Trace
ZA 87 (rep. 1)	Farin Dawa	1*A* Guineensia	Black	++	+	Trace
87 (rep. 2)			Black	++	+	Trace
87 (rep. 3)			Black	++	+	Trace
87 (rep. 4)			Black	++	+	Trace
ZA 91 (rep. 1)	Kaura	2 Caffra	Black	++	+	+
91 (rep. 2)			Black	++	+	+
91 (rep. 3)			Black	++	+	+
91 (rep. 4)			Black	++	+	+
KO 47	Kaura	12 Caffra	Black	++	++	+
PL 11	Jan Dawa	1*E* Guineensia	Red (crimson)	–	++	++
PL 29	Agwachi	1*E* Guineensia	Red (crimson)	–	++	++
PL 10	Farafara	1*A* Guineensia	Straw	–	Trace	Trace
ZA 67	Kaura	2 Caffra	Straw	–	Trace	Trace
ZA 110	Kaura	2 Caffra	Straw	–	Trace	Trace
ZA 58	Far Fara	1*A* Guineensia	White	–	–	–
KB 21 (rep. 1)	Okoli	1*E* Guineensia	Mahogany (dark)	++	+	Trace
21 (rep. 2)			Mahogany (dark)	++	+	++
PL 13	Jinin Kare	1*E* Guineensia	Mahogany (dark)	++	+	+
AD 3 (rep. 1)	Nyanyiri	1*E* Guineensia	Mahogany (dark)	++	++	+
KB 22	Okili	1*E* Guineensia	Mahogany	–	++	++
KB 18	Okili	1*E* Guineensia	Mahogany	–	++	++
AD 1 (rep. 1)	Nyanyiri	1*E* Guineensia	Mahogany (pale)	–	++	++
1 (rep. 2)			Mahogany (pale)	–	++	++
1 (rep. 3)			Mahogany (pale)	–	++	++
1 (rep. 4)			Mahogany (pale)	–	++	++
AD 3 (rep. 2)	Nyanyiri	1*E* Guineensia	Sienna	–	++	++
KO 59	Kaura	2 Caffra	Sienna	–	++	++

rep. = replicate

a partition in favour of the aqueous phase on treatment with amyl alcohol. After hydrolysis this partition was reversed.

These findings suggest that the pigment in millet glumes is a glycoside and that those of sorghum are aglycones. The R_F values of aglycones tabulated by Bate-Smith[4] tend to be higher than the values for the corresponding glycosides. It is conceivable that the glycosides in the glumes of sorghum have undergone glycolysis during maturation and storage of the plant material.

In Table 1, the distribution of pigments, as designated by spots 1, 2 and 3, is illustrated for nineteen different samples. The apparent differences in intensity have been shown on a plus scale. The homogeneity of the results from within groups indicates that differences in level are real, though the effect of maturity and other factors in the differences precludes an interpretation of the results on a quantitative basis. The glumes from replicate heads of three samples, *ZA* 87, *ZA* 91, and *AD* 1, are given to illustrate the reproducibility of the chromatographic analysis within a sample. The table also incorporates the local names, glume colours according to the Quinby terminology and the agronomic groupings devised by Curtis[5] from a modification of Snowden[6]. It will be seen that the most striking and conclusive feature of the chromatographic analysis is the presence or absence of the blue spot 1. This appears in all black and in the so-called dark mahogany samples. Variation occurs in the intensity within groups of spots 2 and 3, but this requires further examination. Pigmentation does not appear to be completely absent in the straw-coloured varieties though spots 2 and 3 appear only after considerable concentration of the extract.

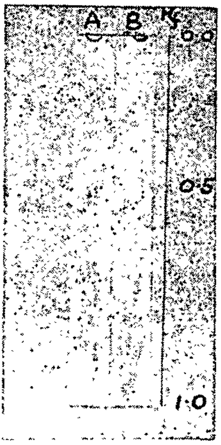

Fig. 1. Typical chromatograms photographed by reflected light. *A*, 'black' (*NG* 119); *B*, 'red' (*PL* 11)

It is not possible at this stage, for reasons given above, to correlate the results with quantitative effects of gene action. On the basis of the blue spot 1 samples can be differentiated into two main groups. The chemical analysis provides an objective classification of samples the glume colours of which range from black through purplish-black and dark mahogany to mahogany. There is no evidence, so far, that the pigment system varies in different groups of Nigerian sorghum. The chromatograms obtained from samples in the different subseries of Snowden are strikingly similar.

The work reported in this communication represents part of a taxonomic survey of sorghum varieties which is being conducted by two of the authors (W. R. S. and D. L. C.). Acknowledgment is made to the Northern Nigeria Ministry of Agriculture for permission to publish these observations.

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Recording Radio Signals from Earth Satellites

Systematic recordings of radio transmissions from an Earth satellite for examination of the ionosphere can be used for providing also, for that particular observing site, the orbit data necessary for the prediction of transit times and the computation of ionospheric influences. For this purpose Doppler frequency shift measurements are particularly useful, and a system has been developed in this Laboratory whereby, with relatively simple equipment, the necessary information from 1958 δ 2 (*Sputnik III*) can be recorded simultaneously with the intensity variations which were previously reported[1]. The intensity variations and frequency samplings are displayed on adjacent cathode-ray tubes and photographed on 35-mm. film moving vertically at a speed of 6 in. per min. A beat-frequency oscillator is used in the receiver and the audio output applied to the horizontal deflexion plates of a cathode-ray tube without a time-base to give a record of the intensity variations as shown at *A* in Fig. 1. The pulse modulation of the transmission is clearly defined, but the 'fading pattern' is also well delineated.

For frequency sampling the same receiver output is applied to the circuitry of the other cathode-ray tube both to trigger a 'single shot' time-base (of adjustable speed and duration) which fires at a pre-set threshold, and simultaneously to apply a vertical deflexion of adjustable size. The result is a series of traces showing the frequency and wave-form of the incident signal as seen in Fig. 1*B*. An adjustable delay allows the time-base to fire at intervals sufficiently long to obviate overlapping of the samples. An audio signal—in this case 500 c./s.—is applied to the cathode-ray tube automatically each minute to serve as time marker and frequency calibration. The adjustments are such that one cycle on the record represents 100 cycles of beat frequency for ease of scaling.

The central line on the record in Fig. 1 is the recorded modulation of Station *WWV* applied on a neon indicator from a separate receiver as a time check.

The total 'Doppler shift' of the 20,005 Mc./s. frequency is of the order of 1,000 cycles, so that the full frequency-range can be covered at good sensitivity while still maintaining reasonable selectivity. In an improved version of the recorder four cathode-ray tubes are used, enabling simultaneous recording of the frequency and intensity variations of the second harmonic as well as the fundamental frequency. Alternatively, two additional intensity recordings can be made as, for example, on two other aerial systems. A more accurate system of time marking has also been incorporated.

This recording system has many good features in addition to its simplicity: it will give a satisfactory sampling on a keyed transmission and through quite severe noise and Morse interference; the wave-form of the received signal is obvious on inspection of the record so that multiple or indirect paths are clearly indicated; the experimental accuracy of the frequency determination can be increased to any extent required by adjustments to the time base, oscillograph and camera; the receiver frequency is crystal-controlled so that, if the transmitter frequency stability is good, as indicated in this case by the consistency of results, the frequency at the central inflexion point will be the actual transmitter frequency and will indicate the time of closest approach; the audio signal can be heard and the frequency display can be observed visually during the recording to give an immediate check on this time; a switch operated by a spring lock adjusted to the local transit period of the satellite makes the recording completely automatic subject to re-setting once a day; the records are easily analysed and the results plotted by relatively unskilled staff; the time of closest approach is established also for the intensity record, facilitating interpretation of the pattern.

With a series of records taken in this way it is possible to smooth out many of the deviations which occur in practice due to transmitter variations, ionospheric irregularities and recording limitations. In a Doppler record of a single transit the feature which can be derived most accurately is the slope of the Doppler-shift curve, $\partial F/\partial t$, at the point of closest approach, a particularly useful quantity for computation. From the values for a series of transits on a number of successive days it is possible to deduce the true value for an overhead transit, which again is a simple case for computation, and also the location of the other transits with reference to the overhead position.

The rate of change $\partial F/\partial t$ has a unique value depending on the height h and velocity V of the satellite and D, the angle between the orbital plane of the satellite and the corresponding zenithal orbital plane.

It is therefore possible from the information obtained above to derive Vh curves for the overhead case and one other defined transit, and the intersection of these curves will establish the velocity and height of the satellite. Derivation of the necessary curves has been simplified by the use of the *Silliac* electronic computer in the University of Sydney. The values compare satisfactorily with those obtained by other means.

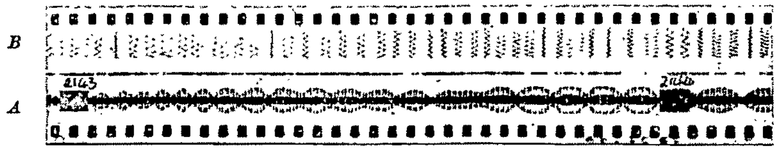

Fig. 1. Record of signals from Satellite 1958 δ 2 (*Sputnik III*). *A*, Intensity; *B*, frequency

Ionospheric effects are more noticeable on the intensity record as changes in the fading pattern. These recordings have been carried out consistently since the end of August, in which time the orbital plane has rotated more than 360°, so that each transit has been observed in both day and night conditions. Analyses are now in progress to examine the effects on the transmission of the variation in satellite height and of seasonal, diurnal and irregular changes in the ionosphere.

This work is the result of a combined effort by the staff of this Laboratory.

G. H. MUNRO
L. H. HEISLER

Sydney Laboratory,
Radio Research Board,
Commonwealth Scientific and
Industrial Research Organization,
Electrical Engineering Department,
University of Sydney.
Jan. 23.

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The Samoan Artificial Aurora

CULLINGTON[1] has recently reported the observation of an aurora-like phenomenon to the south-west of Apia (Samoa) which appears to have been produced by charged particles arriving along lines of force from the site of an atomic explosion, at great altitude in the neighbourhood of Johnston Island, some 2,000 miles distant. The interpretation of this phenomenon has been discussed in some detail by Fowler and Waddington[2] and by Kellogg, Ney and Winckler[3]. Since the particles are clearly guided by the Earth's magnetic field, the impact point for the particles, if we neglect the small drift in longitude, corresponds to the magnetic conjugate point for Johnston Island.

If the geomagnetic field was of purely dipole character, this conjugate point could be obtained in a straightforward manner from geomagnetic co-ordinates. The two points would be on the same parallel of geomagnetic longitude and equidistant from, and on opposite sides of, the geomagnetic equator. However, it is well known from cosmic ray observations that the dipole representation is inadequate when considering the motion of charged particles in the Earth's field. Kellogg *et al.* have therefore calculated the expected position of the aurora on the assumption that the two conjugate points will be symmetrical about the so-called cosmic ray equator.

The behaviour of cosmic rays observed at the surface of the Earth is, however, determined by the geomagnetic field configuration all the way from the surface of the Earth to distances where the field ceases to be effective. The magnetic field lines connecting Johnston Island to Samoa, on the other hand, always lie within about 350 miles of the Earth's surface and consequently we should expect a co-ordinate system based on the surface magnetic field parameters to be more appropriate than one dependent on cosmic-ray observations. We have therefore calculated the position of the conjugate point on the assumption that it should have a magnetic inclination of the same magnitude but opposite in sign to that of Johnston Island and that it should lie on the same magnetic meridian, defined by the direction of the horizontal component of the surface field. This point is marked *A* in Fig. 1, which also shows the two lines of bearing between which the aurora was observed. The distance of the display from Apia is not known since the height of the display is uncertain. The elevation, however, is known to have been 12° and the two thick lines *O* and *O′* correspond to the position of the display assuming that the aurora occurred at a height of 50 miles and 100 miles respectively. The predicted point would correspond to a height of about 70 miles, which is the most frequent height of occurrence of genuine auroral displays at high latitudes.

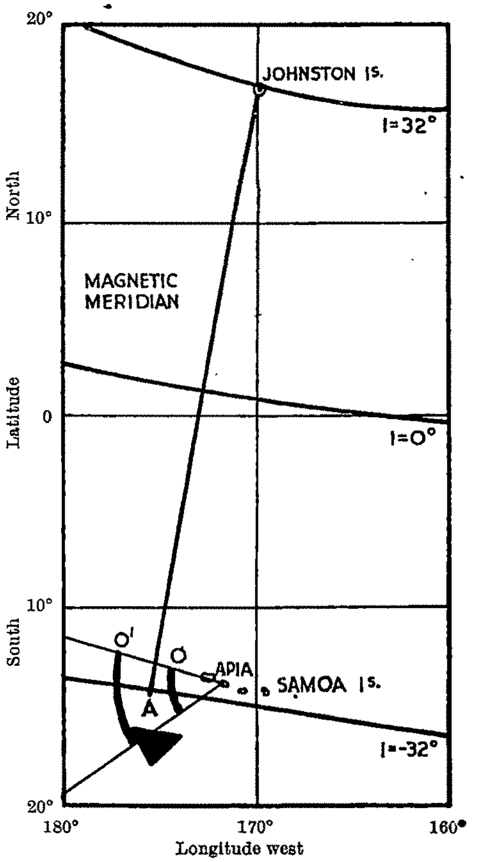

Fig. 1. *A* is the position at which the aurora would be expected. *O* and *O′* are observed positions corresponding to a height of 50 and 100 miles. Black triangle is position of aurora calculated by Kellogg *et al.*

The use of surface-field parameters clearly gives good agreement between the observed and calculated position of the aurora in this case. For high-latitude explosions, however, the guiding lines of force go out to great distances from the Earth and the surface-field values are no longer appropriate. In calculating conjugate points for high-latitude events it is necessary instead to use the co-ordinate system adopted by Quenby and Webber[4] to account for cosmic-ray phenomena.

H. ELLIOT
J. J. QUENBY

Physics Department,
Imperial College of Science and Technology,
London, S.W.7.
Feb. 17.

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New Bands and Lines in the Twilight Sky Spectrum

AT the Abastumani Astrophysical Observatory we have been making continuous observations of the twilight sky for seventeen years, with the view of studying the features of the Earth's atmosphere[1]. In 1957, we began to study the twilight sky spectra by means of a grating spectrograph (grating 135 × 90 mm.^2, 1,200 lines/mm. ; camera, $f = 70$ mm., dispersion 80 A./mm. in the red region). During the year beginning December 1957, 67 spectrograms were obtained in the region 5400–6800 A., of which 29 belong to the morning and 38 to the evening twilight. The well-known lines of oxygen, λλ6300–6364 A. [O I], 5577 A. [O I] and the sodium D-lines 5890–5896 A., are always present on these spectrograms. In addition, some new lines and bands appear permanently or episodically on them. Two such spectrograms are reproduced in Fig. 1. Table 1 contains the wave-lengths of the lines and bands ($\lambda_{\text{obs.}}$), the number of cases of their appearance (n) and the suggested interpretation. This is a preliminary interpretation in so far as in some cases the difference $\Delta\lambda = \lambda_{\text{obs.}} - \lambda$ (λ is an accurate value of the line or band wave-length for a given atom or molecule) reaches the value of 4–5 A., which exceeds the probable error of measurement of $\lambda_{\text{obs.}}$ (1–2 A.). Some additional systematic errors in the determination of $\lambda_{\text{obs.}}$ may have occurred. They may be caused by the high intensity and the complicated structure of the continuous spectrum of the twilight sky, on the background of which one has to study faint lines and bands.

Table 1

Measured (A.)	n	Interpretation				Measured (A.)	n	Interpretation			
		Molecule (or atom)	System	Band	(A.)			Molecule (or atom)	System	Band	(A.)
6784	1	N_2	First positive	(4·1)	6788·6	6469	3	N_2	First positive	(8·5)	6468·5
6757	1	N_2	New		6756			OH	V.-r.	(6·1) R	6470
6741	1	N_2	New		6739	6445	5	C_2			6442·3
6714	1	Ca			6717·8	6403	2				6399
6707	>10	N_2	First positive		6704·8	6395	1	N_2	First positive	(9·6)	6395
		Li			6707·86	6327	1	N_2	First positive	(10·7)	6323
6686	3	CO			6685·7			H_2			6327
					6684·7			Ne			6328
6679	1	N_2	First positive	(5·2)	6675	5952	1	OH	V.-r.		5954
6604	1	A			6604·9	5942	1	H_2O			5942
6591	9	N_2	First positive	(6·3)	6595	5637	1	C_2			5635·5
6577	>10	N_2	New		6578			A			5637·5
		OH	V.-r.	(6·1) P_3	6578			H_2			5636
6544	>10	N_2	First positive	(7·4)	6544·8	5609	3	CO			5610·2
		OH	V.-r.	(6·1) P_2	6546	5606	9	A			5606·9
6538	>10	OH		(6·1)	6538	5557	1	A			5558·7
		A				5480	2	N_2	First positive	(9·4)	5478·5
6525	1	OH	V.-r.	(6·1) P_1	6523	5430	1	C_2			5434·9
6491	2	Ca			6493·1						

There are some bands of molecules of N_2 and OH in Table 1. N_2 is presented by the bands of the first positive system (mainly with the sequence $\Delta v = 3$). Further, we have found two bands of a system which we believe was not hitherto known. These bands were identified recently by Le Blanc, Tanaka and Jursa[2] in a laboratory.

The line $\lambda_{\text{obs.}} = 6707 \cdot 1 \pm 0 \cdot 5$ observed by us probably corresponds to the line $\lambda_{\text{obs.}} = 6708 \pm 1 \cdot 5$ discovered by Delannoy and Weill[3,4] in the twilight spectrum. These authors identify this emission with the resonance line of Li (6707·86 A.). We regard this interpretation as probable, but apparently on our spectrograms the line fuses with the band $N_2 = 6704 \cdot 8$ A.

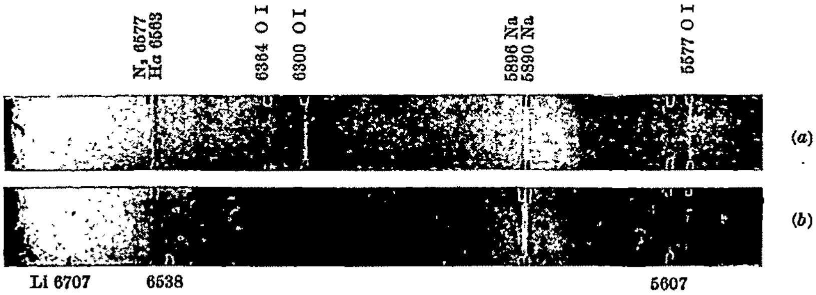

Fig. 1. (a) Augus 22, 1958. [Z = 97° 33′–101° 46′. (b) November 11, 1958. Z = 98°–101° 30′

Our observations are continuing. We intend to publish a fuller account of the observations and particularly to provide information on the height of the layers in which the glow mainly arises.

I. A. KHVOSTIKOV
T. G. MEGRELISHVILI

Abastumani Astrophysical
Observatory,
Mount Kanobili,
Georgia, U.S.S.R.

Jan. 16.

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Density of the Upper Atmosphere

AN important part of the International Geophysical Year Satellite Programme is the use of satellite orbital data for the deduction of atmospheric densities at very high altitudes. Several reports on preliminary results obtained by this method have recently appeared[1,2].

Some years ago, I undertook an analysis of the density of the atmosphere to extreme altitudes[3] for use in connexion with certain theoretical studies of extreme-altitude aerodyna-

Table 1. DENSITY OF THE UPPER ATMOSPHERE (REF. 3)

Altitude (km.)	Model I Density (gm./cm.^{3})	Model II Density (gm./cm.^{3})	Model III Density (gm./cm.^{3})
	Latitude 45°		
200	$5\cdot09 \times 10^{-12}$	$5\cdot09 \times 10^{-12}$	$5\cdot09 \times 10^{-12}$
300	$1\cdot29 \times 10^{-13}$	$1\cdot29 \times 10^{-13}$	$1\cdot29 \times 10^{-13}$
400	$1\cdot16 \times 10^{-14}$	$1\cdot22 \times 10^{-14}$	$1\cdot12 \times 10^{-14}$
500	$1\cdot87 \times 10^{-15}$	$1\cdot95 \times 10^{-15}$	$3\cdot69 \times 10^{-15}$
600	$4\cdot16 \times 10^{-16}$	$3\cdot75 \times 10^{-16}$	$1\cdot54 \times 10^{-15}$
700	$1\cdot10 \times 10^{-16}$	$1\cdot32 \times 10^{-16}$	$8\cdot00. \times 10^{-16}$
1,000	$5\cdot64 \times 10^{-18}$	$4\cdot55 \times 10^{-18}$	$1\cdot65 \times 10^{-16}$
Limit of atmosphere	$2\cdot34 \times 10^{-23}$ (at 8,890 km.)	$2\cdot35 \times 10^{-36}$ (at 8,851 km.)	$2\cdot94 \times 10^{-23}$ (at 70,000 km.)
	Latitude 0°		
200	$4\cdot96 \times 10^{-12}$	$4\cdot96 \times 10^{-12}$	$4\cdot96 \times 10^{-12}$
300	$2\cdot50 \times 10^{-13}$	$2\cdot50 \times 10^{-13}$	$2\cdot50 \times 10^{-13}$
400	$3\cdot32 \times 10^{-14}$	$3\cdot32 \times 10^{-14}$	$3\cdot31 \times 10^{-14}$
500	$9\cdot18 \times 10^{-15}$	$5\cdot14 \times 10^{-15}$	$6\cdot50 \times 10^{-15}$
600	$2\cdot36 \times 10^{-15}$	$2\cdot66 \times 10^{-15}$	$2\cdot98 \times 10^{-15}$
700	$7\cdot95 \times 10^{-16}$	$8\cdot68 \times 10^{-16}$	$1\cdot49 \times 10^{-15}$
1,000	$5\cdot54 \times 10^{-17}$	$6\cdot08 \times 10^{-17}$	$2\cdot94 \times 10^{-16}$
Limit of atmosphere	$4\cdot77 \times 10^{-23}$ (at 10,657 km.)	$6\cdot59 \times 10^{-33}$ (at 14,484 km.)	$2\cdot52 \times 10^{-23}$ (at 60,000 km.)

Table 2. COMPARISON OF UPPER ATMOSPHERE DENSITY

Altitude (km.)	Sterne (ref. 1) Density (gm./cm.^{3})	Harris and Jastrow (ref. 2) Density (gm./cm.^{3})	Grimminger (ref. 3) Density (gm./cm.^{3})					
			Model I		Model II		Model III	
			Lat. 45°	Lat. 0°	Lat. 45°	Lat. 0°	Lat. 45°	Lat. 0°
220	$4\cdot0 \times 10^{-13}$	—	$18\cdot6 \times 10^{-13}$	$25\cdot9 \times 10^{-13}$	$18\cdot6 \times 10^{-13}$	$25\cdot9 \times 10^{-13}$	$18\cdot6 \times 10^{-13}$	$25\cdot9 \times 10^{-13}$
368	$1\cdot4 \times 10^{-14}$	—	$2\cdot6 \times 10^{-14}$	$5\cdot9 \times 10^{-14}$	$1\cdot6 \times 10^{-14}$	$5\cdot9 \times 10^{-14}$	$2\cdot3 \times 10^{-14}$	$5\cdot9 \times 10^{-14}$
405	—	$9\cdot0 \times 10^{-15}$	$11\cdot6 \times 10^{-15}$	$31\cdot4 \times 10^{-15}$	$11\cdot6 \times 10^{-15}$	$31\cdot9 \times 10^{-15}$	$10\cdot6 \times 10^{-15}$	$30\cdot7 \times 10^{-15}$
720	—	$1\cdot2 \times 10^{-16}$	$0\cdot9 \times 10^{-16}$	$6\cdot5 \times 10^{-16}$	$0\cdot9 \times 10^{-16}$	$6\cdot6 \times 10^{-16}$	$7\cdot2 \times 10^{-16}$	$13\cdot1 \times 10^{-16}$
1,000	—	—	$5\cdot6 \times 10^{-18}$	$5\cdot5 \times 10^{-17}$	$4\cdot6 \times 10^{-18}$	$6\cdot1 \times 10^{-17}$	$1\cdot6 \times 10^{-16}$	$2\cdot9 \times 10^{-16}$

mics. The analysis provided density values extending to the outer limit of the atmosphere. The density values at selected altitudes from ref. 3 are shown in Table 1. These are compared in Table 2 with the recently inferred values.

The recent values are derived by somewhat indirect methods and are subject to certain errors previously discussed[1,2]. However, they do have the important advantage of being derived from observational data; whereas the values from ref. 3 especially for altitudes above 300–400 km. are based to a large extent on conceptual models. It is not clear what latitude should be used for purposes of comparison, or whether the average of the values at latitude 45° and latitude 0° would be most appropriate. Or possibly the values for latitude 45° may be accepted as representative of the average value around the Earth (that is, the average from latitude 0° to latitude 90°). Regardless of these uncertainties, it is seen from Table 2 that the recently inferred values generally fall within the range of values given in ref. 3. In fact the agreement is quite close above 300 km. if the values for latitude 45° are used. It is worth noting that the relatively high values of upper atmosphere densities predicted in ref. 3 appear to be verified by the recently deduced values.

GEORGE GRIMMINGER

Directorate of Research and Development,
Headquarters, U.S. Air Force,
Washington, D.C.
Jan. 28.

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Propagation of Finite Elastic Waves in Rubber

THE propagation of finite waves in fluids or solids generally presents considerable difficulty, both theoretically and experimentally. In rubber-like materials, however, the experimental difficulties are greatly reduced; for example, a finite pulse of unloading may be propagated simply by stretching a rubber strip and letting go of one end. A theory of this 'free retraction' has been given by James and Guth[1] and tested experimentally by Mrowca, Dart and Guth[2]. The retraction process is considered as the propagation of a stress pulse from the released tip to the fixed end, the tip itself retracting with such a velocity that the specimen achieves its unstrained state at the instant that the pulse reaches the fixed end.

High-speed cinematographic pictures (at about 2,500 frames/sec.) have confirmed this mechanism qualitatively for natural rubber. Thus in the typical frame in Fig. 1, showing a specimen in the course of retraction from an extension of 300 per cent, the narrow portion of the rubber is stationary and still at the original extension while the wide portion is substantially relaxed and moving with a constant velocity. Quantitatively, however, the theory predicted a velocity $(E/\rho)^{1/2}$ for the pulse based on the wave equation for infinitesimal strains:

$$\rho \frac{\partial^2 u}{\partial t^2} = E \frac{\partial^2 u}{\partial x^2}$$

where ρ is the density, while u is displacement and E Young's modulus, both referred to the unstrained state.

These velocities did not agree with observation, particularly for the more highly strained specimens. Mrowca, Dart and Guth found better agreement by taking the modulus from the slope of the stress strain curve at the extension used. This is formally equivalent to Taylor's treatment[3] for the velocity of plastic waves.

A different way of looking at the problem is to consider the unloading with respect to the stretched

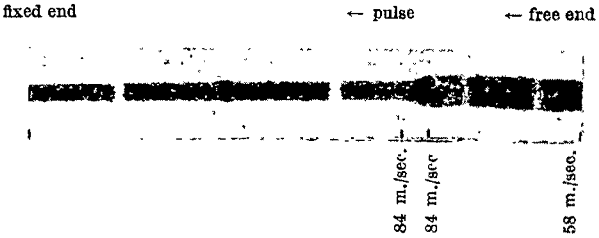

Fig. 1. Retraction of natural rubber from 300 per cent extension

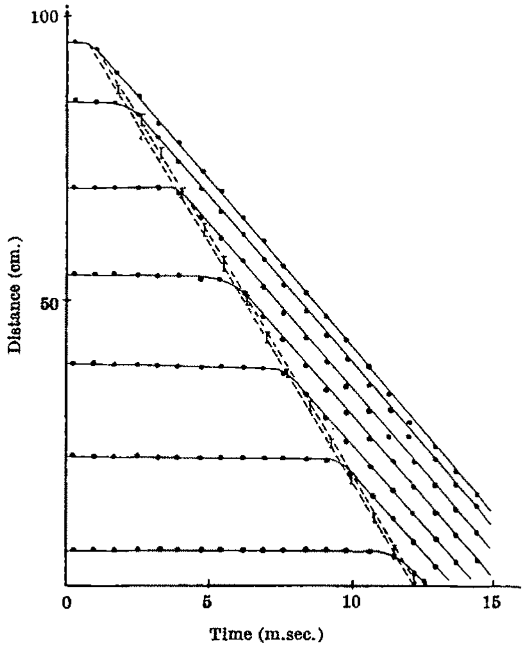

Fig. 2. Analysis of the retraction process. —●—, Reference mar on specimen ; - - -I- - -, unloading pulse

material. It could then be anticipated that, provided the wave-front were not too steep, the head of the pulse would be propagated with the velocity of longitudinal waves of infinitesimal amplitude, $\lambda[(\partial\sigma/\partial\lambda)/\rho]^{1/2}$, σ being the nominal stress and λ the extension ratio. For natural rubber at room temperature there would be little frequency dispersion, but amplitude dispersion would be expected to widen the pulse progressively because of the decrease in velocity as the material relaxes in its passage through the pulse. This is the converse of shock waves in normal solids[4].

Detailed analysis of the film records has been made to check this point, the results for natural rubber retracting from 300 per cent extension being shown in Fig. 2. The passage of the unloading pulse is clearly defined, and it is apparent that there is very little dispersion. The pulse velocity here is 84 m./sec. and the pulse-width approximately 1·5 cm. (0·2 msec. in time) throughout.

Direct measurements of the infinitesimal longitudinal wave-velocity in stretched rubber filaments have already been obtained in another context[5], and Table 1 shows the relation between these values and the velocities of finite pulses observed in retraction for natural and butyl rubbers.

Table 1. Velocities of Finite and Infinitesimal Waves in Stretched Rubber

Rubber	Extension (per cent)	Finite pulse velocity (m./sec.)	Infinitesimal wave velocity at 40° C. (1 kc./s. m./sec.)
Natural	18	46	40
,,	72	45	42
,,	100	57	44
,,	190	62	58
,,	295	84	84
Butyl	42	66	70
,,	122	57	71
,,	209	73	73
,,	328	82	70–84
,,	425	95	97

It thus appears that the velocity of the head of the pulse is substantially the same as that of the infinitesimal waves, but the absence of dispersion is a paradox.

This work forms part of the research programme of the Board of the British Rubber Producers' Research Association.

P. Mason

British Rubber Producers'
Research Association,
48–56 Tewin Road,
Welwyn Garden City,
Herts.

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ENGINEERING

Grinding at Super-Critical Speeds in 'Ball' Mills

In recent years the possibility of grinding materials in machines of the 'ball-mill' type, when running at speeds greater than the critical, has received some attention, and a number of machines operating under these conditions are in industrial use.

The rather limited literature relating to the subject appears, in general, to support the view that the major part of the grinding process arises from the sliding which occurs between the mill shell and the charge, and is localized in this region.

It would appear to be questionable, however, whether such localized action would produce a grinding effect comparable in magnitude with that obtained under sub-critical speed conditions, when grinding occurs between the greater part of the grinding elements in the charge, whereas a grinding effect of this order of magnitude appears to be obtained in practice.

In view of this question the following observations, made upon a small-scale model mill running at 1½ times the critical speed and fitted with a transparent end cover, appear to be relevant and to throw some light upon the nature of the grinding process which occurs under these conditions.

When running at above the critical speed, the charge in the mill oscillates within the mill shell in a pendulum-like manner ; the oscillation being such that, as in Fig. 1*a*, the leading edge of the charge ascends to an altitude of about 45° above the horizontal, at about which position, owing to deceleration

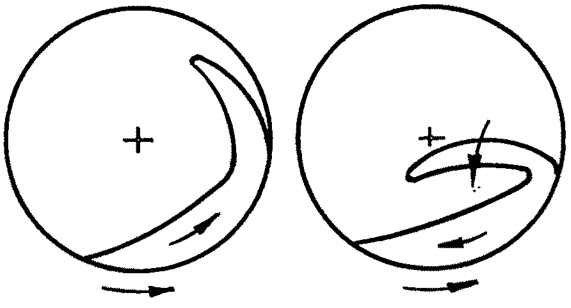

Fig. 1

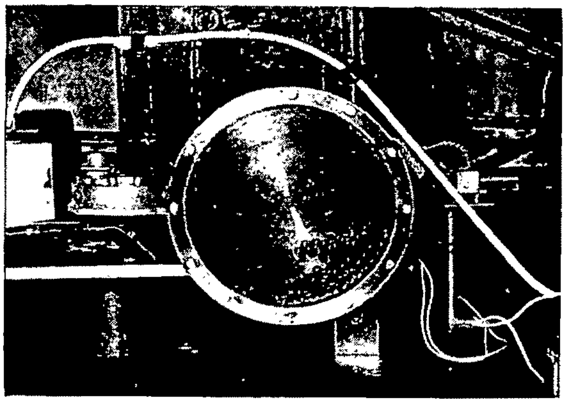

Fig. 2

of the charge due to slip at the mill shell, the leading part of the charge collapses and, as in Fig. 1*b*, falls as a coherent mass upon the lower portion of the charge.

This falling mass of charge is shown clearly in the photograph, Fig. 2.

This falling mass of charge gives rise to a heavy blow, and, in the case of a mill with an autogenous charge, or one in which the powder is in excess of that required to fill the void space between the grinding bodies, this blow could produce a grinding effect which could well be in excess of that arising from the sliding between the charge and the mill shell.

It is also of interest to notice that the descending charge falls upon the remainder of the charge and is not projected upon the mill wall. Thus the condition in which the charge impinges upon the mill liners, a condition which gives rise to excessive liner wear, does not arise.

It has also been observed that, under certain conditions, the slip occurs not at the mill shell but between the charge and the first layer of balls. It is possible that, if this condition could be maintained in practice, wear of the mill liners could, even with super-critical speed milling, be reduced to a magnitude comparable with that encountered in sub-critical speed milling.

H. E. Rose
King's College,
University of London.

M. D. Trbojević
University of Belgrade.
Feb. 13.

METEOROLOGY

Poisson's Law and the Frequency of Hurricanes

Poisson's law, or the 'law of small probabilities' as it is sometimes called, is used at times for describing the probabilities that no, one, two, etc., particular events of a relatively infrequent character will occur in a single year. It has been used in the estimation of the probability of one or more hurricanes striking a given area, say, New England, in a year. The purpose of this communication is to point out weaknesses inherent in this treatment, and to suggest one or more alternative approaches.

In the development of Poisson's law, it is assumed that the occurrence of a single event of the specified sort neither increases nor decreases the probability of occurrences of another event of the same sort. Thus in the use of Poisson's law in the estimation of the probabilities of hurricanes, it is tacitly assumed that the arrival of a single hurricane in the specified region neither increases nor decreases the probability that another hurricane will strike the region in the near future. In other words, hurricanes striking a given area are considered as entirely independent events. This would imply that such a thing as a trend or regular pattern does not exist.

There are two types of arguments which could be used for supporting the idea of a trend in hurricanes. In one, it is argued that once a hurricane has passed through a region, the energy available to feed a hurricane has been diminished, and there is less chance of a hurricane striking the area than previously.

In the other thesis, one would argue that the arrival of one hurricane demonstrates that conditions are favourable for such an occurrence, and that therefore the probability of the arrival of another hurricane in the area is greater than previously. The latter argument appears likely to have the greater appeal to those meteorologists supporting the idea of a trend.

As a particular case, consider the Caribbean hurricanes striking New England, which is here taken as that part of the United States east of the Hudson River and north of Long Island Sound. Observational data, which are not necessarily complete or entirely accurate, indicate that twelve hurricanes have moved into this area in 320 years (up to 1953). This can be used as the basis of a Poisson distribution:

$$1 = e^{-z}(1 + z + z^2/2 + z^3/6 + \ldots \text{etc.})$$

where the successive terms on the right represent the probabilities of no, one, two, etc., hurricanes striking in a single year. Thus for Caribbean hurricanes striking New England:

$$ze^{-z} = 3/80 = 0{\cdot}0375$$

which gives $z = 0{\cdot}039$ and $e^{-z} = 0{\cdot}96175$. Hence, according to Poisson's law, the probabilities of no, one, two, three hurricanes in New England in a single year are 0·96175, 0·03750, 0·00073, 0·00001 respectively. This would imply that New England will, on the average, have a year with two hurricanes about every 1,370 years, a year with three hurricanes once in a hundred thousand years. The year 1954 provided the area with enough two-hurricane years for more than a thousand years and came near to supplying a three-hurricane year. ('Hazel' 1954 passed somewhat to the west of the Hudson River.) Yet another hurricane flooded New England the following year.

Looking again at Poisson's law, it is seen that it says two things: (1) that the sum of the probabilities is one which means that there will certainly be no hurricane or one hurricane or two hurricanes, etc., in a year; (2) that the ratio between consecutive terms, say, between the $(n + 1)$st and the nth is z/n, or in other words, the ratio of the probability of n hurricanes in a year to the probability of $(n - 1)$ hurricanes in a year is only slightly greater than $1/n$ of the probability of one hurricane in a year.

This last statement gives a clue to a possible approach to the problem of deciding whether a trend exists. When observations have been made over a sufficiently long period to determine approximately the frequency of years with no, one, two hurricanes, the ratios of the frequencies, $F_0 : F_1 : F_2$ can be taken as approximations to the ratios of the probabilities, $P_0 : P_1 : P_2$. One can then ask: Is $2P_2/P_1$ approximately equal to P_1/P_0? If the first ratio is significantly different from the second, Poisson's law cannot be used in this problem with any confidence.

If Poisson's law is not to be used, what can be done? Clearly the sum of all the probabilities must remain 1; the only thing which can be changed is the ratio between consecutive terms. If experience shows that the consecutive terms in Poisson's law diminish too rapidly, that the law indicates fewer two-hurricane years than usually occur, the ratio of consecutive terms should be increased, perhaps from z/n to z as a first trial. The series of probabilities corresponding to this assumption is:

$$1 = V(1 + z + z^2 + \ldots + z^n + \ldots)$$

where V must be chosen so that the sum of all terms on the right is 1. But for small values of z (a standard restriction imposed in the use of Poisson's law):

$$1 + z + z^2 + z^3 + \ldots + z^n + \ldots = 1/(1 - z)$$

Hence $V = (1 - z)$ and the series becomes:

$$(1 - z)(1 + z + z^2 + \ldots + z^n + \ldots)$$

To use this with the data for New England hurricanes, $(1 - z)z = 3/80 = 0{\cdot}0375$ and $z = 0{\cdot}0390$. The corresponding sequence of probabilities is 0·96098, 0·03750, 0·00146, 0·00006. According to this, the probabilities of two-hurricane years and three-hurricane years are approximately double and six times the corresponding probabilities as estimated by Poisson's law.

But even this may not match the actual frequency of two-hurricane and three-hurricane years. To increase the ratios between consecutive terms even more, one may try:

$$1 = W(1 + z + 2z^3 + 3z^3 + \ldots + nz^n + \ldots)$$

Then $W = (1 - z)^2/(1 - z + z^2)$ and the sequence becomes:

$$1 = \frac{(1-z)^2}{1-z+z^2}(1 + z + 2z^2 + 3z^3 + \ldots + nz^n + \ldots)$$

Applying this to the above data for New England hurricanes:

$$\frac{z(1 - z)^2}{1 - z + z^3} = 0{\cdot}0375 \text{ and } z = 0{\cdot}039095$$

and the sequence of probabilities is 0·95920, 0·03750 0·00293, 0·00034. This sequence provides probabilities of two- and three-hurricane years four and thirty-six times those given by Poisson's law. Recalling that New England has had one year with two hurricanes in about 325 years, the probability of a two-hurricane year can, on the basis of past experience, be taken as about 0·003. This is equal to the largest value of the corresponding probability of the three given above.

This suggests that with the arrival of one hurricane in New England, the probability of a second one within the year is somewhat greater than was that of a first one, say, four times as great. This may be counted as evidence that there is such a thing as a trend in hurricanes. Even the slightest evidence of regularity is encouraging, since it implies there is hope that some day, with a better understanding of hurricanes, their motions can be predicted with greater certainty.

CHARLES H. SMILEY

Ladd Observatory,
Brown University,
Providence 12,
Rhode Island.
Jan. 22.

CHEMISTRY

Potentiometric Titration of Coal in a Non-Aqueous Medium

Brooks and Maher[1] have determined the groups in a wide range of Australian coals which contain acidic oxygen by titration of a suspension in anhydrous ethylenediamine, using sodium amino-ethoxide in ethylenediamine as the titrant. They used two antimony electrodes, one in the reaction medium and the second built into the burette tip, where it was washed continuously by the titrant. The use of the basic solvent ethylenediamine permitted the titration of carboxylic acid groups and probably the more strongly acidic phenolic groupings, though Fritz and Keen[2] state that some substituted phenols are too weakly acidic to be titrated, as are some polyhydric phenols such as resorcinol and catechol, where no definite end-point can be located. However, according to van der Heijde and Dahmen[3], increased basicity of the solvent does not lead to an increased apparent acidity of weak (that is, non-levelled) acids. If there is any influence at all it works in the opposite direction.

In the present work *n*-butylamine has been used as the solvent and sodium methoxide in benzene/methanol solution as the titrant. The apparatus was essentially that of Brooks and Maher[1], with the exception that the electrode in the burette tip was of platinum–10 per cent rhodium alloy instead of antimony. The platinum–rhodium electrode was connected to the positive terminal, and the antimony electrode in the reaction medium to the negative terminal, of a Pye 'Master' *p*H meter, both leads being screened and earthed. Under the conditions used by Brooks and Maher the addition of titrant resulted in a fall in e.m.f. and it was necessary to allow a period of at least 1 hr. after the addition of the solvent to the coal for equilibrium to be reached before the start of the titration. With *n*-butylamine, however, a maximum of 15 min. stirring was all that was necessary before a constant mV.-reading was obtained and the titration started. The platinum–rhodium versus antimony electrode combination results in an initial e.m.f. of between −400 and −500 mV., which becomes increasingly negative as the titration proceeds.

A number of British coals, ranging in rank from 201 to 902 and in carbon content from 92 to 79 per cent, have been titrated. The quantitative results are set out in Table 1 and two of the curves obtained when the volume of titrant is plotted against mV. are shown in Figs. 1 and 2. While the high-rank coals of more than 90 per cent carbon show little or no differentiation and a low content of titratable acidity, the lower-rank coals show interesting qualitative differences. The shape of the curves (though not the titre) is the same for coals of the same rank, and the differences between coals of different rank are apparently indicative of changes in structure. However, the interpretation of these titration curves is difficult since the occurrence has been reported[4] of anomalous curves due to acid–anion association and also because of the possibility that internal hydrogen bonding[5] will lead to enhanced acidity. Evidence of the existence of hydrogen-bonded phenolic hydroxyl groups in a number of coals has been put forward by Brown and Wyss[6].

The determination of the phenolic hydroxyl groups in coal has been carried out by Wyss[7] using an acetylation method. He found that the proportion of the total oxygen present as acetylatable hydroxyl groups varied between 35 and 44 per cent for coals of carbon content ranging between 77 and 89 per cent, and that above 89 per cent carbon there was a sharp drop in this proportion to 10 per cent or less. In the present work the range is wider, coal of 79–86 per cent carbon showing a proportion of 30–49 per cent of the total oxygen present as titratable acidic groups. There is some indication also that the higher proportions are localized in the range 84–86 per cent carbon in agreement with the work of Mazumdar[8]. The results for the high-rank coals (Nos. 1–6) are higher than those obtained by Wyss ; but the accuracy is doubtful because of the low titres involved and the consequent enhanced effect of the blank correction.

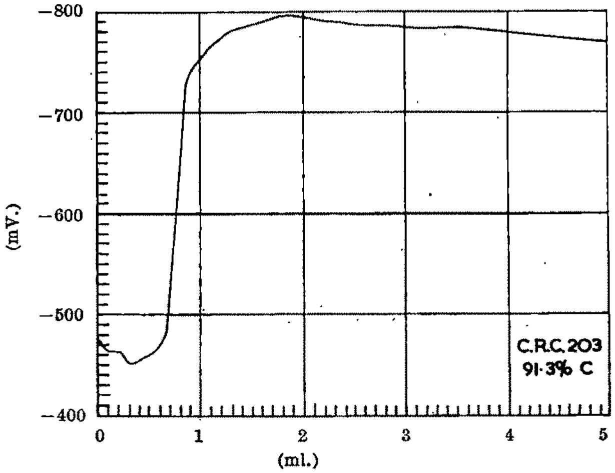

Fig. 1

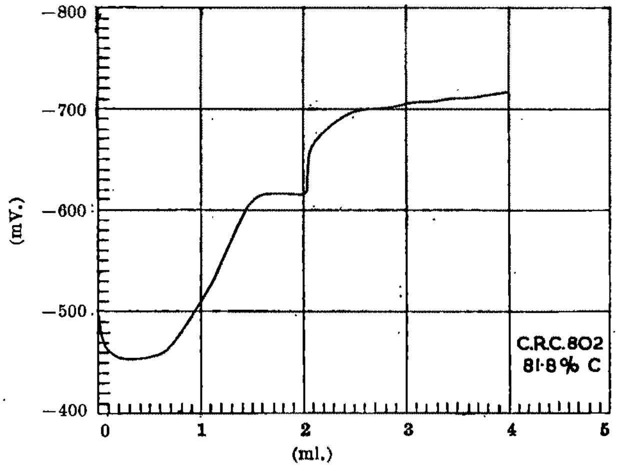

Fig. 2

Table 1

Coal	Coal rank code	Percentage of dry matter (mineral-free basis)			O_{OH} as per cent of total O
		C	O	O_{OH}	
1	201	92·2	1·65	0·54	32·7
2	201	91·8	2·24	0·43	19·2
3	202	91·0	2·58	0·35	13·6
4	203	91·3	2·31	0·84	36·4
5	204	90·5	2·51	0·68	27·1
6	301*a*	90·8	2·29	0·34	14·8
7	401	86·6	5·99	2·41	40·2
8	501	85·1	6·50	2·36	36·3
9	501	84·7	7·20	3·45	47·9
10	502	84·1	7·76	3·85	49·6
11	502	86·6	5·57	2·63	47·2
12	700	82·7	10·20	3·98	39·0
13	702	81·7	10·25	3·83	37·4
14	802	81·8	10·90	3·33	30·6
15	902	81·0	11·61	4·57	39·4
16	902	79·0	13·20	4·18	31·7

Work is proceeding on a wider range of coals and with alternative titrants in an effort to improve the precision of the method.

W. J. S. Pringle

National Coal Board,
Coal Survey Laboratory,
Birmingham. Feb. 5.

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Electrolytic Deposition of Beryllium

Beryllium is of interest in the atomic energy field because of its low absorption and high scattering cross-section for thermal neutrons. The metallurgical properties and nuclear applications of the metal have been reviewed recently[1]. The electrolytic deposition of beryllium from solutions of beryllium compounds in organic solvents[2] and in liquid ammonia[3] has been studied. In the most recent work[4], published immediately before completion of the present investigation, coherent deposits of beryllium of up to 95 per cent purity were obtained during the electrolysis of a solution containing dimethyl beryllium and beryllium chloride etherate in ethyl ether. Deposits obtained from this bath were superior to the powdery deposits obtained by electrolysis of a 2·8 *M* solution of $BeCl_2.2(C_2H_5)_2O$ in ethyl ether. Although one of the commercial methods of manufacturing beryllium involves the high-temperature electrolysis of beryllium chloride[5], in alkali halide melts the possibility of recovery and electro-refining of scrap metal by anodic dissolution and cathodic deposition has received little attention.

In the present work a number of non-aqueous systems have been examined with the view of finding a system from which coherent coatings of high-purity beryllium could be obtained on electrolysis. The anodic dissolution and cathodic deposition of beryllium in molten salt baths has also been studied[6].

All organic solvents were dried for long periods over an appropriate desiccant and distilled before use. Gaseous ammonia was condensed over sodium before distillation into the electrolysis cell. Commercial grade beryllium chloride was purified by reaction

Table 1. ELECTROLYSES IN SOLUTIONS CONTAINING BERYLLIUM CHLORIDE AT 20° C.

Solvent	Cathodic current density (amp. dm.$^{-2}$)	Deposits obtained on electrolysis
Liquid ammonia (−33° C.)	1·0–5·0	Black reactive deposits
Piperidine	0·015	Grey metallic streaks containing beryllium
Pyrrole	0·015–2·0	Grey metallic streaks containing beryllium
Aniline	0·15	Black tarry deposit
Ethylenediamine	1·0	Black non-metallic deposit
Ethylenediamine + NH_4CNS	1·0	Black non-metallic film
Methyl cyanide	1·0	Gassing at electrodes—no deposit

Table 2. ELECTROLYSES IN ETHEREAL SOLUTIONS OF BERYLLIUM CHLORIDE AND BERYLLIUM DIMETHYL AT 20° C.

Solution	Cathodic current density (amp. dm.$^{-2}$)	Deposit obtained on electrolysis
5 per cent w/v $Be(CH_3)_2$	0·15	Smooth, brittle, black metallic deposit
5 per cent w/v $Be(CH_3)_2$ with added $BeCl_2$	1·0–2·5	Black, flaky, metallic deposit containing 30 per cent beryllium
5 per cent w/v $BeCl_2$	0·2	Shiny, black metallic film
2·5 *M* $BeCl_2.2(C_2H_5)_2O$	1·0	Metallic flashes of beryllium

with hydrogen at 300° C. to reduce ferric iron to non-volatile ferrous iron, followed by distillation. All transfer operations were carried out in an inert atmosphere in a glove box and the electrolyses were carried out in an atmosphere of pure, dry oxygen-free nitrogen or argon. Platinum or beryllium anodes and copper cathodes were used throughout.

The results are given in Tables 1 and 2. Only traces of black, non-metallic deposits were obtained in liquid ammonia solutions of beryllium chloride, in agreement with the observations of Wood and Brenner[4]. The solubility of beryllium chloride in piperidine, pyrrole, aniline and ethylenediamine was low (20–30 gm./l.). Although the grey streaks obtained on the cathode during prolonged electrolyses (several days duration) in piperidine and pyrrole were shown by spectrographic analysis to contain beryllium and appeared metallic under the microscope the results were not sufficiently encouraging to warrant extended investigation of these systems. Electrolyses carried out in solutions of beryllium dimethyl and mixtures of beryllium dimethyl and beryllium chloride in ethyl ether led to the preparation of smooth black coatings. These deposits, although lustrous when examined microscopically, were impure. The coatings obtained during the electrolyses of 2·5 *M* solutions of the compound $Be2Cl_2.2(C_2H_5)_2O$ in ethyl ether were more lustrous than those obtained above but were still impure.

By far the most promising results were obtained from the beryllium chloride etherate bath at 150° C. Prolonged electrolysis (7 days) was necessary before bright, thin films of metallic beryllium were obtained. Initially, gassing occurred at the electrodes followed by the appearance of powdery deposits and finally coherent films. Spectrographic analyses indicated that only beryllium was present in these coatings. The impurities iron, nickel and aluminium normally associated with beryllium were found to be absent.

The anodic dissolution of beryllium in molten eutectic mixtures of lithium and potassium chlorides and sodium and beryllium chlorides at 400° C. was also investigated. Beryllium dissolved anodically in these baths with high current efficiency at current densities up to 50 amp. dm.$^{-2}$. High-purity beryllium in the form of flakes was recovered at the cathode. Growth lines similar to those observed on electrolytic titanium deposited from fused chloride systems[7] have been observed on the flake metal.

We wish to thank Dr. J. Sackman for the preparation of samples of beryllium dimethyl for electrolysis and the United Kingdom Atomic Energy Authority for permission to publish this work.

I. A. MENZIES
D. L. HILL
L. W. OWEN

United Kingdom Atomic Energy Authority,
Atomic Weapons Research Establishment,
Aldermaston.

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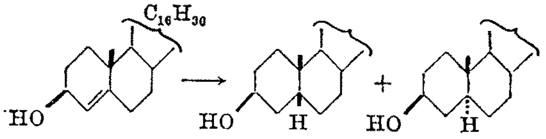
Effect of Alkali Salts on the Steric Course of Hydrogenation of a Cyclic Allylic Alcohol

INSPECTION of the literature reveals that hydrogenation of many, but not all, cyclic allylic alcohols gives products in which at least one hydrogen has been added to the same side of the molecule as the hydroxyl group. Thus, Schoenheimer and Evans[1] reported that hydrogenation of allocholesterol (I) in amyl ether solution in the presence of a platinum catalyst gave coprostanol (in unstated yield). A re-investigation of this reaction was undertaken in an attempt to determine more precisely the influence of hydroxyl or other neighbouring groups on the stereochemistry of hydrogen addition.



(I) (II) (III)

It was found that cholestanol (III) and a hydrocarbon fraction were always obtained along with coprostanol (II) when allocholesterol was hydrogenated in ethanol solution in the presence of an Adams platinum catalyst. Further work showed

Table 1

Catalyst		Yields (per cent)		
		II	III	Hydrocarbon
A_1	Adams catalyst	67	25	5
A_2	Adams catalyst	70	24	6
B_1	Catalyst A_1 pre-reduced and thoroughly washed with water	10	15	74
B_2	Catalyst A_2 similarly treated	19	22	59
C_1	Catalyst B_1 + $NaNO_3$ (1 per cent of catalyst weight), in solution	57–64	30–36	0–9
C_2	Catalyst B_2 + $NaNO_3$ (1 per cent)	66	27	7

Catalysts A_1 and A_2 were made by heating chloroplatinic acid and 'Analar' sodium nitrate in the respective weight ratios 1 : 20 and 1 : 50 at 420° C. for 1 hr., followed by washing with distilled water until sodium nitrate had been removed.

that the small amounts of sodium salts normally present in Adams catalyst[2–4] greatly affected the course of the reaction.

The highest yields of coprostanol were obtained by hydrogenation of allocholesterol in the presence of catalysts prepared *in situ* from the hydrated dioxide obtained from the fusion process (cf. catalysts *A*). When sodium salts were removed by pre-reduction of the dioxide and washing, the yields of hydrocarbon (hydrogenolysis products) were increased largely at the expense of coprostanol (cf. catalysts *B*). The properties of the original catalysts *A* could apparently be reconstituted by the addition of small amounts of various sodium salts (cf. catalysts *C*).

It will clearly be advisable in future work on the stereochemistry of olefin hydrogenation promoted by platinum catalysts to determine the effect of alkali salts, present extraneously or added deliberately.

M. C. DART
H. B. HENBEST

The Queen's University of Belfast.
Feb. 4.

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Cohesive Energy Density of Polystyrene

Bristow and Watson[1] have recently described the determination of the cohesive energy densities of polymers by swelling and viscosity measurements. This communication summarizes the results of viscosity measurements on polystyrene solutions directed towards a similar end. The measurements cover a slightly different range of solvents from that of Bristow and Watson, and in some solvents a range of molecular weights has been investigated.

Values of the polymer–solvent interaction constant μ are obtained using the Flory–Fox[2] equations :

$$\alpha^5 - \alpha^3 = C'(1 - 2\mu + x^{-1/2})M^{1/2}/V_1$$

$$\alpha^3 = [\eta]/[\eta]_\theta$$

where x is the chain-length of the polymer, V_1 is the molar volume of the solvent, and $[\eta]$ and $[\eta]_\theta$ are the experimentally determined intrinsic viscosities in the solvent and 'ideal' solvent, respectively. Values of μ obtained in this way (at 25° C.), and taking[3] $C' = 3{\cdot}0$, for a polystyrene ($\overline{M}w$ = 300,000) are given in Table 1. That these results are slightly higher than those of Bristow and Watson is in part attributable to their use of an $\overline{M}n$ value. Also listed are some values obtained from swelling measurements[3] from another set of viscosity measurements[3], from osmotically determined second virial coefficients[4] and from vapour-pressure measurements[5]. The agreement is reasonably satisfactory. The viscosity method should yield lower values than either swellings or vapour pressures, and this is borne out, particularly in the case of the solvents butanone and *n*-propyl acetate. It is noteworthy that the results reveal the expected[6] decrease of V_1 with increase of α, though the points scatter appreciably.

Table 1

Solvent	This work		μ (Ref. 1)	μ (*a*)	μ (*b*)	μ (*c*)	μ (*d*)
	$[\eta]$	μ					
Chloroform	1·070	0·459	0·429	0·43	0·452	—	—
Benzene	1·020	0·460	0·438	0·45	0·435	—	—
Tetrahydrofuran	1·020	0·460	—	—	—	—	—
Toluene	0·990	0·453	0·432	0·44	0·438	0·434	0·44
Dioxane	0·920	0·476	—	—	0·466	0·472	—
Nitrobenzene	0·721	0·493	—	—	—	—	—
n-Propyl acetate	0·557	0·507	—	—	—	—	0·64
Butanone	0·546	0·511	0·506	0·53	0·506	0·485	0·66
'Ideal'	0·405	(0·519)	—	—	—	—	—

(*a*) From swelling measurements (ref. 3).

(*b*) From viscosity measurements; $[\eta]_\theta$ calculated from $[\eta]_\theta = 7{\cdot}3 \times 10^{-4} M^{1/2}$; $\overline{M}w$ = 370,000.

(*c*) From osmotic second virial coefficient; $\overline{M}w$ = 750,000.

(*d*) From vapour pressure measurements (ref. 5).

The dependence of μ on molecular weight was investigated at 25° C. in three solvents, and typical results are given in Table 2, together with some values derived from other work[7]. All reveal the same trend, namely, increase of μ with decrease of molecular weight. A similar but rather small trend is shown by the values calculated from osmotic second virial coefficients, using the simple Huggins's expression and provided the term $x^{-1/2}$ is taken into account (0·472, 0·481 and 0·484, respectively, in toluene).

The cohesive energy densities are related, according to Huggins[8], by the equations:

$$\mu = \beta + V_1(\delta_1 - \delta_2)^2/RT$$

where δ_1 and δ_2 are the values for solvent and polymer, respectively, and β is a further parameter. A plot of

Table 2

$\overline{M}w \times 10^{-3}$	1,040		625		169		1,500*	290*	72*
Solvent	$[\eta]$	μ	$[\eta]$	μ	$[\eta]$	μ	μ	μ	μ
Benzene	2·80	0·436	1·83	0·445	0·587	0·485	0·437	0·438	0·474
Toluene	2·45	0·440	1·67	0·450	0·560	0·483	0·429	0·448	0·472
Butanone	1·29	0·500	0·918	0·502	0·355	0·521	0·496	0·508	0·527
'Ideal'	0·778	(0·510)	0·585	(0·513)	0·301	(0·525)	(0·508)	(0·519)	(0·538)

* $\overline{M}n$ by osmometry ; $[\eta]_\theta$ calculated from $[\eta]_\theta = 7{\cdot}3 \times 10^{-4} M^{1/2}$.

$(\delta_1^2/RT) - (\mu/V_1)$ against δ_1 gave $\delta_2 = 8{\cdot}73$ (cal./cm.$^3)^{1/2}$ from the present measurements on $\bar{M}w$ = 300,000. (The results in Table 2 reveal no dependence of δ_2 on molecular weight but measurements in a wider range of solvents are needed for this point to be substantiated.) Bristow and Watson found $\delta_2 = 8{\cdot}56$ (cal./cm.$^3)^{1/2}$. Both sets of measurements combined cover a range of δ_1 from 7·82 to 10·4 (cal./cm.$^3)^{1/2}$, but the highest and lowest points deviate somewhat from the line. Omitting these we find $\delta_2 = 8{\cdot}76$ (cal./cm.$^3)^{1/2}$ and $\beta \sim 0{\cdot}4$. Viscosity measurements interpreted in this way thus lead to a value of 75 ± 2 cal./cm.^{3} for the cohesive energy density of polystyrene.

I thank Mr. J. S. Powell for some of the measurements. This work is published by permission of the Director of the National Chemical Laboratory.

J. H. S. Green

National Chemical Laboratory,
Teddington, Middlesex. Jan. 14.

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Biosynthesis of Rubber

Bandurski and Teas[1] have shown that rubber in *Hevea brasiliensis* has its origin in acetate, although Park and Bonner[2] have been unable to repeat these observations, and could not show the incorporation of β-hydroxy-β-methylglutarate or of β-methylcrotonate into rubber. The acetate pathway, with its analogies in fatty acid and sterol biosyntheses, remains very attractive. Mevalonate has been incorporated into rubber[2]; but Barlow and Patrick[3] were unable to show its incorporation after application to *Hevea* leaves and stems. Much of the acetate administered to *Hevea* seedlings is directed towards respiratory metabolism[4]. The results of our experiments on incorporation of acetate and mevalonate cast some doubt on the validity of the conclusions of Bandurski and Teas.

Hevea brasiliensis latex, freshly tapped from 7-year-old trees growing under glass in Birmingham, was incubated at 28–35° with sodium-1-^{14}C-acetate, sodium-2-^{14}C-acetate and 2-^{14}C-mevalonic lactone, with and without the co-factors used by Bandurski and Teas[1]. The latex used was shown to be a good source of co-enzyme *A* [5]. After investigation of several different extraction procedures, the rubber was obtained finally as a poly-(dibromo-*iso*prene) prepared by the method of Gowans and Clark[6]. The reproducibility of this method was checked by the infra-red spectrum of the micro-crystalline bromo-compound, which showed a strong absorption peak at 775 cm.$^{-1}$, probably associated with the C—Br linkage[7]. Counting methods used comprised both gas-phase counting of carbon dioxide labelled with carbon-14 obtained by dry combustion in oxygen and solid counting on aluminium disks. Typical results, using sodium-1-^{14}C-acetate, are shown in Table 1. It should be pointed out that even at the highest value obtained by Bandurski and Teas only $10{\cdot}7 \times 10^{-4}$ μmole of acetate had been incorporated into rubber in 8 hr. We have been unable to observe the incorporation *in vitro* of mevalonate into rubber with the aid of fresh latex.

Table 1. INCORPORATION OF ACETATE INTO RUBBER

Mixture incubated	Poly-(dibromo-*iso*prene) c.p.m./mgm. rubber carbon
Acetate + 0·1 ml. latex without co-factors	9
Acetate + 1·0 ml. latex without co-factors	23
Acetate + 1·5 ml. latex with co-factors + sucrose	0
Bandurski and Teas (ref. 1) results :	
Acetate + 0·1 ml. latex without co-factors	26
Acetate + 0·1 ml. latex with co-factors + sucrose	297

A search was made for other possible biosynthetic intermediates, notably β-hydroxy-β-methylglutaric acid and β-methylcrotonic acid, formed during the metabolism of sodium-1-^{14}C- and -2-^{14}C-acetate, by modifications of the method of Rabinowitz and Gurin[8]. After halting the reactions by the addition of metaphosphoric acid, carrier compounds were added to the incubated mixtures of latex and acetate. Crystalline compounds were isolated, purified by repeated recrystallizations and paper chromatography. Paper autoradiography of the isolates failed to reveal any radioactivity associated with β-hydroxy-β-methylglutaric or β-methylcrotonic acids. Similarly, after incubation of latex with labelled mevalonate, no evidence could be obtained for the formation of possible breakdown products (β-hydroxy-β-methylglutaric or β-methylcrotonic acids), as suggested by reactions catalysed with flax enzymes[9]; it appeared that most of the mevalonate remained unchanged.

It is realized that the *Hevea* trees used in this investigation did not approach in size or latex yield the trees used by Bandurski and Teas, but it must be stressed that the role of both acetate and mevalonate as rubber precursors is by no means established. Until an overall carbon balance for the fate of these precursors when added to isolated enzyme and co-enzyme systems from latex has been completed, it is unlikely that a definitive assessment of the results of radioactive experiments can be made.

We acknowledge the constant advice and interest of Prof. M. Stacey, and thank Dr. R. H. Cornforth for a sample of 2-^{14}C-mevalonic lactone, Dr. J. C. Bevington for help with radioactive measurements and the Dunlop Rubber Co., Ltd., for the award of a scholarship to one of us (P. J.).

J. A. Gascoigne*
Patricia Jones

Department of Chemistry,
The University,
Birmingham 15.
Jan. 28.

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* Present address: British Rayon Research Association, Wythenshawe, Manchester 22.

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BIOCHEMISTRY

Feulgen–Naphthoic Acid Hydrazide Reaction applied to Blood Smears

HÆMATOLOGICAL use of Schiff's reagent for the Feulgen reaction[1] has been described by Gardikas and Israels[2]. This technique, or minor variations of it, has been used extensively to identify the number of nucleoli in primitive normal or pathological leucocytes. There is a perinucleolar concentration of nuclear protein, but the nucleoli themselves are free of deoxyribonucleic acid.

The method has one disadvantage in that deep staining cannot be obtained and smears must usually be examined for the specific red coloration with the aid of a green sub-stage filter. The purpose of this communication is to direct attention to the naphthoic acid hydrazide reaction described by Pearse[3,4]. A modification of Pearse's method has been found to give excellent results with smears of blood or bone marrow from a number of species (man, horse and dog). The intensity of staining available with fast blue *B* is considerably greater than that available with Schiff's reagent. The method is as follows.

Fresh, air-dried smears are fixed for 30 sec. on the staining bridge with a solution consisting of 10 ml. of 40 per cent formaldehyde and 90 ml. of absolute methanol kept in the refrigerator at 0° C. The smears are rinsed in distilled water and then in *N* hydrochloric acid. Hydrolysis is performed at 60° C. for 10 min. in *N* hydrochloric acid. After this the smears are again rinsed in *N* hydrochloric acid, in distilled water, and in 50 per cent ethyl alcohol. They are incubated for 5 hr. in naphthoic acid hydrazide at 20–22° C. made up as follows: 0·1 gm. 2-hydroxy-3-naphthoic acid hydrazide (L. Light and Co.) is dissolved in 50 ml. absolute ethanol. 45 ml. distilled water and 5 ml. glacial acetic acid are then added. After incubation the slides are immersed in three changes of 50 per cent ethyl alcohol for 10 min. each, rinsed in distilled water, and stained in freshly prepared fast blue *B* at 0° C. for 3 min. prepared as follows. Fast blue *B* (G. T. Gurr) 5 mgm. dissolved in 0·1 *M* veronal buffer *p*H 7·4, 5 ml. The buffer is kept in the refrigerator in small jars of 5 ml. capacity to which the fast blue *B* is added just before staining. The latter is performed in a Petri dish in the refrigerator. The slides are then washed in distilled water and blotted dry.

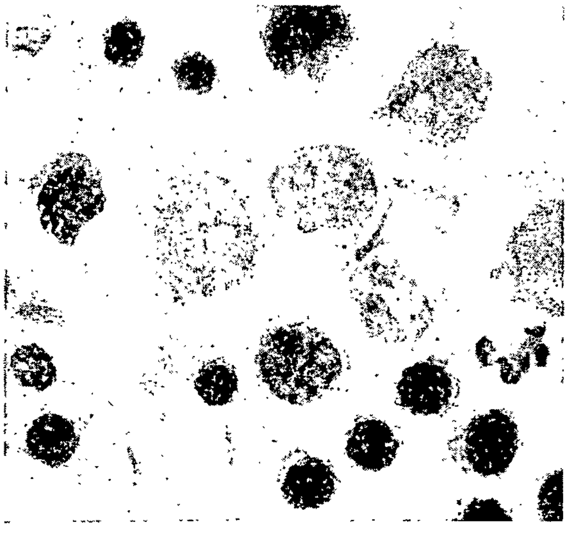

Fig. 1. The Feulgen–naphthoic acid hydrazide reaction applied to a smear of horse bone marrow. Deoxyribonucleic acid stains bluish-purple. Cytoplasm stains faint pink

Using this technique Fig. 1 illustrates a typical group of cells from a horse bone marrow specimen. Deoxyribonucleic acid stains bluish-purple while the cytoplasm of the cells stains a faint pink. The smears are easily seen microscopically without light filtration and the distribution of the bluish-purple fast blue *B* stain is identical with that of the more usual Schiff reagent in the Feulgen reaction.

R. K. ARCHER

Equine Research Station,
Animal Health Trust,
Newmarket.

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Destruction of Cortisone and Related Steroids by Traces of Copper during Purification Procedures

WE wish to report the destruction of μgm. quantities of cortisone and related steroids by traces of cupric ion and the prevention of such destruction by addition of ethylenediamine tetraacetic acid.

In the course of developing paper chromatographic procedures for the purification and estimation of adrenal steroids in urine, poor recoveries of cortisone and cortisol were obtained repeatedly. In addition, the simultaneous formation of several transformation products was observed.

The cause of the destruction was traced ultimately to the glassware, which routinely had been washed in hot detergent solution ('Diflex'), rinsed with distilled water, and dried in an oven. Analysis of the distilled water revealed the presence of approximately 1 mgm. of copper/l. Two 125-ml. Erlenmeyer flasks received from the washroom on separate days contained 2·7 and 3·0 μgm. copper. Special treatment of test-tubes with sulphuric acid–dichromate, followed by repeated rinsing with copper-free water obtained from a de-ionizer, greatly reduced the loss of added steroid but did not prevent it completely. However, the prior addition of a small amount of ethylenediamine tetraacetic acid, even to tubes not especially pretreated, resulted in quantitative recoveries of added cortisone.

In a typical experiment 4 μgm. of cortisone in 10 μl. of methanol was added to each of three 'Pyrex' test-tubes, size 100 mm. × 10 mm., only the first of which had been washed in sulphuric acid–dichromate and rinsed with copper-free water. The second tube served as a control, and 50 μgm. of disodium ethylenediamine tetraacetic acid in 0·5 ml. of methanol was added to the third tube. 1 ml. of methanol was added around the sides of each tube, and then evaporated in a stream of carbon dioxide. After being allowed to stand for 3 hr. at room temperature, the residues were transferred individually with two 25-μl. portions of methanol to spots on a 7-in. sheet of unwashed Whatman No. 1 paper. Cortisone standards of 0·5–4·0 μgm. were added in spots along the same line. Chromatography was performed by Bush's[1] system *C* after an overnight equilibration. By a procedure similar to that of Neher and Wettstein[2], quantitation was done on the bases of blue tetrazolium reduction and of soda fluorescence. The recoveries from the tube washed in sulphuric acid–dichromate and rinsed with copper-free water, that washed in the routine manner, and that washed in the routine manner and treated with 50 μgm. ethylenediamine tetraacetic acid were 95, 62 and 100 per cent, respectively.

Destruction was accompanied by the appearance of three new spots on the chromatogram. One spot was at the origin, another was just below the origin, and the third spot had migrated 1·45 times as far as the cortisone. The derived substances absorbed illumination at 254 mμ and gave soda fluorescence, but in the quantities obtained they did not reduce blue tetrazolium. Artefacts were not formed in detectable amounts from the fresh cortisone standards which were transferred from the stock solutions in methanol directly to the paper. However, in stock solutions which initially contained 4 μgm./10 μl., artefacts were detectable 2 weeks after they had been prepared. But in the presence of 10 μgm. of disodium ethylenediamine tetraacetic acid per ml. of methanol, artefacts were not detectable in solutions of cortisone and cortisol 8 weeks after they had been prepared.

The effect of addition of 1 μgm. copper (as cupric chloride) on cortisone and a number of related steroids was studied. All glassware was washed with acid and rinsed with copper-free water. 10 μl. of water which contained 1 μgm. copper was poured into a test-tube and taken to dryness in a desiccator. 4 μgm. of steroid in 10 μl. of methanol was added and the sides of the test-tube were rinsed with 1 ml. of methanol. The remainder of the procedure was as described above. Recoveries of all steroids from such control test-tubes not containing added copper were essentially quantitative. The recoveries of cortisone and cortisol after addition of 1 μgm. of copper were 50 and 75 per cent, respectively ; recoveries were quantitative when both 1 μgm. copper and 50 μgm. ethylenediamine tetraacetic acid were added. 1 μgm. copper caused considerable loss of 11-dehydrocorticosterone and smaller losses of corticosterone, aldosterone, and Reichstein's substance *S*, but had no effect on 21-deoxycortisone. (Chromatography for evaluation of recovery of these five substances was performed by Bush's system *B*, except that Bush's system *C* was used for aldosterone.) The order of decreasing ease of destruction was as follows: cortisone > cortisol > 11-dehydrocorticosterone > corticosterone > substance *S* > aldosterone > 21-deoxycortisone.

In order to determine the effect of ethylenediamine tetraacetic acid on the recovery of a steroid from paper chromatography, 10-μgm. samples of cortisone were chromatographed (formamide–chloroform) along two 5-cm. lines on a sheet of Whatman No. 1 paper impregnated with 30 per cent formamide and 70 per cent acetone. When the solvent front was near the bottom of the paper, zones 6 cm. high by 7 cm. wide containing the steroid were cut out and eluted chromatographically with 15 ml. of water. The water was extracted with three 5-ml. portions of chloroform. 50 μgm. disodium ethylenediamine tetraacetic acid in 5 ml. of methanol was added to one chloroform extract, and 5 ml. of methanol to the other. The solutions were taken to dryness *in vacuo*, the residues were transferred to test-tubes with 2 ml. of methanol, and the solutions were taken to dryness in a stream of carbon dioxide. The residues were dissolved in methanol and divided into one-, five- and ten-sixteenths, and taken to dryness in carbon dioxide. After standing for a day, the residues were transferred to paper, chromatographed and evaluated as above. The recoveries in the experiments with and without addition of ethylenediamine tetraacetic acid were 93 and less than 5 per cent. In similar experiments with cortisol the recoveries were 88 and 42 per cent. Detergent-washed glassware was used in these experiments.

The presence of copper and other metals in filter paper and the use of 8-hydroxyquinoline for preventing their interference in the chromatography of amino-acids have been described by Consden, Gordon and Martin[3]. Although we have not chromatographed cortisone or cortisol on paper containing chelating agents for metals, such a procedure might improve still further the recovery of these compounds. In our experience losses of cortisone and cortisol due to contaminants obtained from the glassware have been much more serious than those due to contaminants obtained from paper.

It seems probable that the destruction of cortisone and cortisol in the experiments involving the routinely washed glassware was due, at least in part, to copper. We think so because : (1) the distilled water and glassware contained significant amounts of copper ; (2) the addition of copper to specially cleaned glassware resulted in destruction of the steroids with the formation of transformation products of the same chromatographic mobility as those obtained from using ordinary glassware ; (3) the addition of ethylenediamine tetraacetic acid prevented destruction of the steroids under both sets of conditions.

Frequently, copper is present in the water (natural or distilled[4,5]), tongs, vessels, or other apparatus used to clean glassware. It seems probable that the destruction of steroids by copper may occur in laboratories other than our own.

We wish to thank Dr. Harold L. Mason for helpful suggestions during the course of this work.

Marvin L. Lewbart
Vernon R. Mattox

Section of Biochemistry,
Mayo Clinic and Mayo Foundation,
Rochester, Minnesota. Jan. 5.

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Differential Effect of Phenothiazines on Oxidative Phosphorylation

In a previous communication[1] we directed attention to the biochemical effect of chlorpromazine on electron transport and the coupled phosphorylation. While studying related compounds we have observed that promethazine hydrochloride (10-(2-dimethyl amino-*iso*propyl) phenothiazine hydrochloride) exerts differential effects on the phosphorylations coupled to the reduction of cytochrome *c* by β-hydroxybutyrate and by succinate. Table 1 shows that promethazine hydrochloride inhibits the phosphorylation coupled to oxidation of β-hydroxybutyrate by 30 per cent at 2×10^{-4} and $4 \times 10^{-4}\,M$. At the latter concentration, electron transport is powerfully inhibited. The phosphorylation coupled to succinate oxidation is inhibited 50 per cent at $2 \times 10^{-4}\,M$

Table 1. EFFECT OF PROMETHAZINE ON OXIDATIVE PHOSPHORYLATION

Substrate	Concentration of promethazine × 10^{-4} M	Oxygen uptake (μgm.-atoms)	Phosphorus uptake (μmoles)	P/O	Inhibition P/O (per cent)
β-Hydroxybutyrate	nil	7·5	18·5	2·5	—
β-Hydroxybutyrate	2	6·6	10·2	1·67	33
β-Hydroxybutyrate	4	1·2	2·3	1·80	28
Succinate	nil	12·5	21·0	1·7	—
Succinate	2	12·4	10·5	0·84	50
Succinate	4	11·6	2·3	0·2	82
Ferrocytochrome *c*	nil	10·9	6·5	0·6	—
Ferrocytochrome *c*	2	9·3	0·0	—	100

Systems: Adenosine triphosphate, 0·0017 M; potassium chloride, 0·025 M; magnesium sulphate, 0·0067 M; cytochrome *c*, 2 × 10^{-5} M; sodium inorganic orthophosphate buffer, *p*H 7·2, 0·01 M; glucose, 0·03 M; hexokinase solution, 0·05 ml. Substrate 0·01 M.

Enzyme systems: For β-hydroxybutyrate oxidation, mitochondria suspended in 0·5 ml. of 0·075 M sucrose, equivalent to 1·5 mgm. nitrogen. For succinate, mitochondria, 0·5 mgm. nitrogen were suspended in 0·5 ml. of 0·02 M phosphate, *p*H 7·2, 0·25 M sucrose, in which medium they were pre-incubated for 10 min. at 30° C. For ferrocytochrome *c*, mitochondria, 2 mgm. nitrogen, were added in 0·5 ml. 0·075 M sucrose. 0·01 M ascorbate was added as reducing agent. Final vol. 3·0 ml.

Incubation temperatures were 38° C. for β-hydroxybutyrate and succinate and 20° C. for ferrocytochrome *c* oxidation.

and essentially abolished at 4×10^{-4} M, electron transport being little affected. A one-step oxidation was secured by pretreatment of mitochondria, as described by Hunter and Ford[2]. Table 1 also shows that the inhibitor abolishes the phosphorylation coupled to oxidation of ferrocytochrome *c*.

Table 2. EFFECT OF PROMETHAZINE ON PHOSPHORYLATION COUPLED TO CYTOCHROME *c* REDUCTION

Substrate	Promethazine (4×10^{-4} M)	Cytochrome *c* reduced (mμ moles)	Phosphorus esterified (mμ moles)	P/2*e*	Inhibition P/O (per cent)
β-Hydroxybutyrate	—	63·2	59·0	1·87	—
β-Hydroxybutyrate	+	18·5	17·9	1·92	nil
Succinate	—	53	7·3	0·28	—
Succinate	+	38	nil	—	100

System: Cytochrome *c*, 4 × 10^{-5} M; sodium inorganic orthophosphate buffer, *p*H 7·2, 0·005 M; glucose, 0·03 M; hexokinase, 0·05 ml.; sodium cyanide, 10^{-4} M; ethylenediamine tetraacetate, 10^{-3} M; adenosine triphosphate, 0·0017 M; magnesium sulphate, 0·0067 M; potassium chloride, 0·025 M; phosphorus-32 to an activity of 80,000 c.p.m. per μmole; where present, β-hydroxybutyrate was added at a concentration of 0·01 M and succinate at a concentration of 0·033 M. Temperature, 20° C. Method of determination of phosphate uptake that of Nielsen and Lehninger (ref. 3). Mitochondria (0·04 mgm. nitrogen) in 0·1 ml. of 0·075 M sucrose. Final vol. 3·0 ml.

Table 3. EFFECT OF PROMETHAZINE ON ^{32}P-ADENOSINE TRIPHOSPHATE EXCHANGE

Additions	Promethazine (2×10^{-4} M)	Phosphorus-32 counts/min. incorporated into adenosine triphosphate	Inhibition (per cent)
Nil	nil	5,950	nil
30 μmoles β-hydroxybutyrate	nil	6,070	nil
Nil	+	2,025	66
30 μmoles β-hydroxybutyrate	+	4,600	24

System: Adenosine triphosphate, 0·0017 M; inorganic orthophosphate, *p*H 7·2, 0·0033 M; magnesium sulphate, 0·0067 M; potassium chloride, 0·025 M; *tris* buffer, *p*H 7·2, 0·03 M; versene 10^{-3} M; phosphorus-32, 15,000 c.p.m. (spec. act., 1,500 c.p.m. per μmole). Time of incubation, 15 min. Temperature, 20° C. Mitochondria (1·0 mgm. nitrogen) added in 0·5 ml. 0·25 M sucrose.

The experiments recorded in Table 2 show that promethazine hydrochloride does not affect the efficiency of phosphorylation coupled to reduction of cytochrome *c* by β-hydroxybutyrate, even though electron transport is inhibited by more than 50 per cent. In this respect it resembles chlorpromazine. When cytochrome *c* is reduced by succinate, however, the phosphorylation is abolished by 4×10^{-4} M promethazine hydrochloride. It follows that promethazine selectively inhibits two sites of phosphorylation. One is that coupled to the oxidation of ferrocytochrome *c* and the other that coupled to the span succinate – cytochrome *c*. Promethazine hydrochloride also inhibits powerfully the ^{32}P-adenosine triphosphate exchange reaction. This agrees with the similar action of chlorpromazine. The inhibition is partially reversed by addition of β-hydroxybutyrate, which has no effect on exchange in the absence of inhibitor (Table 3). The inorganic phosphate-level does not alter appreciably in these experiments. This result indicates that inhibition of the exchange reaction is not due to any uncoupling effect of the compound, and suggests that the greater part of the exchange occurs between the span reduced diphosphopyridine nucleotide – cytochrome *c*.

At high concentration the phenothiazines are inhibitors of several flavoprotein enzymes, and we suggest that the difference in effect of promethazine hydrochloride on reduced diphosphopyridine nucleotide – cytochrome *c* reductase and succinate cytochrome *c* reductase reflects the difference in structure of the enzymes and lends support to the view that the flavoproteins themselves take part in the initial stages of the oxidative phosphorylation reaction.

We should also like to direct attention to the specificity of action of these compounds on oxidative phosphorylation reactions. Hitherto no compound capable of stepwise inhibition of the respiratory phosphorylations has been described.

J. D. JUDAH
K. R. REES
M. J. R. DAWKINS

Department of Morbid Anatomy,
University College Hospital Medical School
and Department of Biochemistry,
University College, London.

Jan. 13.

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Condensation Products of Ethylenediamine with Adrenaline

IT has been reported that adrenaline and noradrenaline are converted quantitatively into strongly fluorescent stable products by their reaction with ethylenediamine[1,2], and the fluorimetric separation determination of adrenaline and noradrenaline was devised by the use of two kinds of secondary filters, based on the difference of the fluorescence spectra of the condensation products of both catechol amines[3].

It was supposed that the separation of these condensation products by chromatography or electrophoresis and the determination of each fluorescence might be applied for the separation determination of adrenaline and noradrenaline on the basis of the ethylenediamine method. Starting from this point of view, we intended to separate the condensation products of adrenaline and noradrenaline by means of paper chromatography or paper electrophoresis, and encountered the unexpected result that one of the by-products of the condensation reaction of adrenaline with ethylenediamine was identical with the main condensation product of noradrenaline.

The sample of L-adrenaline (Merck Co.) used was examined by chromatography. When it was tested by paper chromatography using phenol containing 15 per cent (v/w) 0·1 *N* hydrochloric acid as solvent[4] and coloured by potassium ferricyanide, only one spot appeared. Only one peak was also observed by *IRC*-50 column chromatography[5]. Therefore, the presence of noradrenaline in this sample could be excluded. Using this sample of L-adrenaline, the condensation was carried out.

5 μgm. of adrenaline dissolved in 10 ml. of 0·01 *N* hydrochloric acid were added to a mixture of 1 ml. of ethylenediamine monohydrate and 0·5 ml. of 2 *M* ethylenediamine dihydrochloride, heated at 50° C. for 20 min. and extracted with 6 ml. of *iso*-butanol as reported by Weil-Malherbe and Bone[2]. In order to concentrate the fluorescent derivatives, 5 ml. of the *iso*-butanol extract were condensed under reduced pressure at about 30° C. and redissolved with a small amount of water. This sample, containing the condensation products corresponding to about 0·3 μgm. of adrenaline, was placed on a strip of Whatman No. 1 filter paper which was previously treated with 0·5 *N* hydrochloric acid and then with 0·1 per cent ethylenediamine tetraacetate[6]. The paper strip was developed in the dark, and the condensation products were examined under ultra-violet light. When the upper layer of *n*-butanol/ethanol/5 per cent $Na_2HPO_4 \cdot 12H_2O$ (50 : 25 : 30)[7] was used, the following three fluorescent spots appeared: weak violet fluorescent spot at R_F 0·32, yellow fluorescent spot at R_F 0·48, and bluish-green fluorescent spot at R_F 0·71. (When the concentration of adrenaline was increased, several other fluorescent derivatives appeared.)

The violet fluorescent spot at R_F 0·32 was considered to be derived from the substance contained in the filter paper. The reasons are as follows: (1) this spot could also be observed in the case of the blank test without adrenaline; (2) ethylenediamine, when applied on the filter paper, formed a violet fluorescent spot which is easily extractable with hot water and has the same fluorescence spectrum as that of the extract from the spot at R_F 0·32. So this violet fluorescent spot was attributed to the reaction of ethylenediamine dissolved in *iso*-butanol with the substance contained in filter paper.

The strongest yellow fluorescent spot, at R_F 0·48, was the main product which is specific for adrenaline.

The bluish-green fluorescent spot at R_F 0·71 was considered to be identical with the main spot of noradrenaline derivatives as described below.

In the case of noradrenaline, three spots were observed as follows: yellow fluorescent spot at R_F 0·04, violet fluorescent spot at R_F 0·32, and bluish-green fluorescent spot at R_F 0·71.

The strongest bluish-green fluorescent spot at R_F 0·71 was the main condensation product which is specific for noradrenaline.

The identification of the bluish-green fluorescent derivative of adrenaline (at R_F 0·71) with the main fluorescent derivative of noradrenaline was further carried out by paper chromatography using the following different solvents: the upper layer of *n*-butanol/methanol/5 per cent $Na_2HPO_4 \cdot 12H_2O$ (60 : 15 : 30)[7], the upper layer of *n*-propanol/*n*-butanol/5 per cent $Na_2HPO_4 \cdot 12H_2O$ (50 : 15 : 30)[7], *n*-butanol-saturated phosphate buffer at *p*H 6·0[8], *n*-butanol/conc. ammonia (9 : 1)[9], and 5 per cent $Na_2HPO_4 \cdot 12H_2O$.

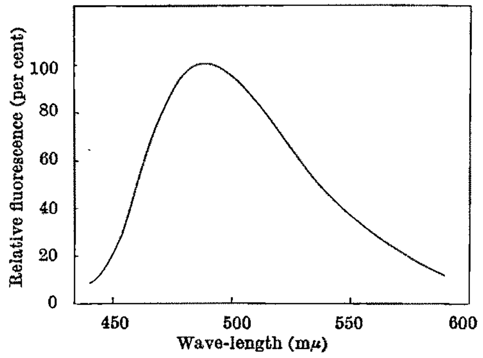

Fig. 1. Fluorescence spectrum of the main condensation product of ethylenediamine with noradrenaline and that of the by-product in the condensation of ethylenediamine with adrenaline. Samples were dissolved in *iso*-butanol, and were excited by ultra-violet radiation (365 mμ). The ordinate shows the relative intensity of the fluorescence

In each case, R_F value of the bluish-green fluorescent by-product of the adrenaline derivative agreed with that of the main noradrenaline derivative.

Paper electrophoresis was also used to examine the products. The sample was placed on the anode side of a paper strip moistened with 0·05 *M* phosphate buffer (*p*H 7·0) and 1 m.amp./cm. of constant current was applied in the dark. The violet fluorescent band derived from the filter paper moved rapidly to the cathode. Then, the main product which fluoresced yellow moved more rapidly than the bluish-green fluorescent band, which has the same rate of mobility as the main product fluorescing bluish-green of noradrenaline derivative.

As shown in Fig. 1, the fluorescence spectrum of *iso*-butanol extract of the bluish-green fluorescent spot of adrenaline derivative was identical with that of the main noradrenaline derivative. They agreed with that of the major product of noradrenaline reported by Nadeau and Joly[3].

*p*H-fluorescence curves of aqueous extracts of both derivatives were identical, as shown in Fig. 2.

These results confirm the identity of the two bluish-green fluorescent substances. Accordingly, it was considered that the condensation reaction of ethylenediamine with adrenaline gave the main

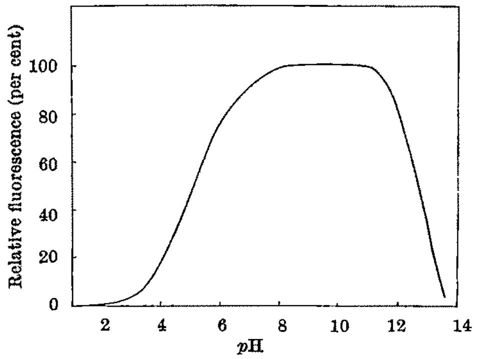

Fig. 2. *p*H-fluorescence curve of the main condensation product of ethylenediamine with noradrenaline and that of the by-product in the condensation of ethylenediamine with adrenaline. The relative intensity of the fluorescence of the substance excited by ultra-violet radiation (365 mμ) was measured at *p*H indicated. Samples were dissolved into 0·1 *M* glycine hydrochloric acid (*p*H 1–4), 0·1 *M* phosphate (*p*H 5–8), 0·1 *M* glycine sodium hydroxide (*p*H 9–13) buffers and 1 *N* sodium hydroxide

condensation product of noradrenaline as one of its by-products. This fact indicates that the demethylation of adrenaline occurs during the condensation reaction of adrenaline with ethylenediamine.

KUNIO YAGI
Department of Biochemistry,
TOSHIHARU NAGATSU
Department of Neuropsychiatry,
School of Medicine,
University of Nagoya.
Dec. 22.

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PHYSIOLOGY

Pattern of Recurrent Conditioning of Spinal Reflexes

VARIOUS functions have been suggested for the recurrent conditioning described by Renshaw[1]. Consonant with his view that the conditioning is "not obviously related to reciprocal innervation"[1], others have considered the widespread inhibitory action to serve a "generalized suppressor function"[2]; or to stabilize the impulse output in the stretch reflex at a slow rate[3]. As recurrent inhibition is prominent between the nuclei of two heads of a muscle or of two parts of a muscle group, it has been thought to help in the localization of stretch reflexes[4]. Following the finding that recurrent facilitation is evoked by activity of the cholinergic motor axon collaterals[5], as is recurrent inhibition[2], the distribution of these two actions has been re-examined. Contrary to some previous descriptions, it now appears that the distribution of recurrent conditioning displays an integrated pattern which is in some respects related to reciprocal innervation.

All experiments were performed on acutely decapitate cats in which the carotid arteries were tied off and the vertebral arteries clamped. The dorsal roots were cut from *L* 3 or *L* 4 to *S* 3, and various roots were stimulated to elicit test monosynaptic reflexes in a variety of muscle nerves. For conditioning, other muscle nerves were stimulated antidromically, the impulses entering the cord through the intact ventral roots. The preparations were immobilized by intravenously injected 'Flaxedil' (gallamine triethiodide, American Cyanamid Co.).

As Renshaw noted[1] the conditioning action between any two nerves remains essentially the same from one experiment to another. Some differences, however, do occur. Recurrent conditioning often consists of a mixture of facilitation and inhibition. In systems where facilitation is the predominant action, an early inhibitory phase may sometimes be present. When such an inhibitory phase is present, its magnitude and the conditioning-test interval at which it reverses to facilitation vary from one preparation to another. Similarly, where inhibition is predominant, it may be followed by a facilitatory overshoot. In some systems there has been a variation in the type of conditioning observed. For example, when flexor longus digitorum was used to condition the dorsiflexors of the digits, facilitation and inhibition were observed on different occasions.

One generalized finding from these experiments is that recurrent facilitation appears most often when reflexes in nerves to flexor muscles are conditioned by antidromic stimulation of nerves to extensors. When extensor reflexes are conditioned by flexor nerves there is frequently no effect, although some facilitation and inhibition have been obtained. When extensors condition extensors, or flexors condition flexors, inhibition is usually seen. In the case of interactions between muscles acting at different joints, exceptions to this general pattern have been found.

The organized pattern of the conditioning actions becomes still clearer when examined in terms of interactions of antagonists at various joints. These results are presented in Table 1.

Table 1

Joint	Nerve used to condition	Nerve used for testing	Effect
Digits	plantaris	extensor longus digitorum extensor brevis digitorum	facilitation, usually preceded by some inhibition
	flexor longus digitorum*	extensor longus digitorum extensor brevis digitorum	facilitation preceded by inhibition, or inhibition
	deep peroneal	plantaris flexor longus digitorum	weak mixed action or no effect
Ankle	gastrocnemius-soleus	tibialis anterior extensor longus digitorum	facilitation, sometimes preceded by some inhibition
	deep peroneal	gastrocnemius-soleus	little effect
Knee	quadriceps†	biceps-semitendinosus	facilitation
	biceps-semitendinosus	quadriceps	some facilitation, at times preceded by inhibition

* In all experiments flexor longus digitorum included the nerve to tibialis-posterior.
† The nerve to rectus femoris was usually removed.

At all joints studied, antidromic stimulation of the nerves to the extensors resulted in a conditioning action on the flexors which was predominantly facilitatory. Antidromic stimulation of the flexors had a facilitatory action on the extensors at the knee, but only weak indeterminate effects on the ankle and digit extensors. In the case of the ankle and digits the facilitatory action by the extensors was not restricted to their specific antagonists; stimulation of gastrocnemius-soleus, plantaris and flexor longus digitorum resulted in facilitation of all branches of the deep peroneal nerve.

Whereas antidromic stimulation of the extensors facilitates their antagonists, there is recurrent inhibition of their synergists, and frequently, of extensors at neighbouring joints. For example, it is known that antidromic stimulation of part of quadriceps inhibits the reflex in another part of the muscle[1]; the same interaction is found between the heads of gastrocnemius[1]. Antidromic stimulation of gastrocnemius-soleus inhibits plantaris and flexor longus digitorum. An inhibitory action between these latter two muscles has also been reported[2].

It has been held that the presence of recurrent inhibition between various nuclei is determined by their proximity in the spinal cord[2]. While proximity may indeed be a factor, it is not sufficient to account for all results that have been obtained. This can be seen particularly clearly in experiments involving biceps posterior-semitendinosus and biceps anterior. The motoneurons of these muscles can be shown to have the same segmental distribution in the cord and are known to form a single nucleus[6]. Yet when these nerves are used either for testing or conditioning quite different results are obtained: quadriceps consistently facilitates biceps posterior-semitendinosus but has an inconstant action on biceps anterior; biceps posterior-semitendinosus inhibits tibialis anterior, which is facilitated by biceps anterior.

In conclusion, our results support the view that recurrent conditioning in the cat spinal cord is determined by more than the location of nuclei in the ventral horn. Rather, an integrated pattern appears to be present. Where pronounced recurrent conditioning is present between muscles of a myotatic unit, this conditioning is opposite in action to the monosynaptic facilitation or direct inhibition between the same muscles. This is particularly evident when activity in flexors is conditioned by stimulation of extensors.

V. J. Wilson
W. H. Talbot
F. P. J. Diecke

The Rockefeller Institute,
New York.
Feb. 6.

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Effect of Morphine upon the Adrenal 17-Hydroxycorticosteroid Secretion in the Dog

It has been reported that morphine is a potent stimulus to the anterior pituitary–adrenal cortical system, as judged by indirect index such as depletion of adrenal ascorbic acid in rats[1-3]. However, little is known quantitatively of adrenal corticosteroid secretion in response to morphine. In the present investigation, experiments were carried out to evaluate directly the effect of morphine upon the secretion-rate of 17-hydroxycorticosteroids in dogs.

In order to collect the adrenal venous blood in unanæsthetized dogs, the method of Satake *et al.*[4] was used with a slight modification. About three weeks before the experiments proper, the thoracic (11)–lumbar (3) dorsal spinal roots, through which the sensory nerve fibres from the lumbar area run, were cut under 'Evipan-sodium' and ether anæsthesia. The lumbo-adrenal vein cannulation was performed without anæsthetizing the animal. Then about 18 hr. were allowed to elapse before the onset of experiments. After control adrenal venous blood samples were collected without anæsthetizing and fastening the animal, morphine hydrochloride in a dose of 8 mgm./kgm. body-weight was injected intravenously in 60 sec.

5, 10, 20, 30, 60 and 120 min. after morphine injection, the adrenal venous blood collections were also made. The plasma was separated from the sample of blood by centrifugation and was estimated for 17-hydroxycorticosteroids by use of Nelson and Samuels's method[5]. The rate of secretion was calculated by multiplying the 17-hydroxycorticosteroid content of the adrenal venous blood plasma by the adrenal plasma flow.

Table 1. Effect of Morphine upon the Adrenal 17-Hydroxycorticosteroid Secretion-Rate in the Dog

No. of experiment	17-Hydroxycorticosteroid secretion-rate (μgm./kgm./min.)							
	Min. before morphine injection		Min. after morphine injection					
	30	10	5	10	20	30	60	120
1	0·05	0·07	—	0·67	—	0·41	0·09	0·07
2	0·06	0·05	0·67	0·74	0·21	0·06	0·06	0·06
3	0·12	0·13	0·30	0·92	0·59	0·72	1·0	0·15
4	0·08	0·08	1·2	1·5	1·4	1·6	1·1	1·0
5	0·06	0·13	2·0	2·7	2·4	2·2	2·1	1·3

The results are given in Table 1.

The resting secretion-rate was measured as 0·05–0·13 μgm./kgm. body-weight/min., the mean value being 0·08 μgm. After morphine injection the secretion-rate increased invariably. Within 10 min. after the injection a remarkable increase was observed in all cases. The maximal secretion-rate after morphine was measured as 0·67, 0·74, 1·0, 1·6 and 2·7 μgm./kgm./min.

Tatuzi Suzuki
Kazukuni Yamashita
Seiichi Zinnouchi
Takaaki Mitamura

Department of Physiology,
Nagasaki University School of Medicine,
Nagasaki.
Jan. 3.

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Prolonged Muscular Activity without Phosphate Exchange

Although there is a paucity of direct supporting evidence for the postulate that the immediate source of the energy for muscular contraction is the dephosphorylation of adenosine triphosphate, this view has been accepted by most authors[1-3]. The usual finding that there is no net decrease in the amount of adenosine triphosphate present in the working muscle is attributed to its rapid resynthesis by transfer of the phosphate group of phosphocreatine. However, Fleckenstein *et al.*[4] found no evidence for such transfers of phosphate groups in a tracer study on drug-induced contracture of muscles of the frog, and Dixon and Sacks[5] found no evidence for equilibration of isotopic phosphorus between the terminal phosphorus of adenosine triphosphate and phosphocreatine in the course of a tetanic contraction of the cat gastrocnemius muscle of 30 sec. duration. Nor was there any equilibration of the isotope between the middle phosphorus of adenosine triphosphate and the corresponding phosphorus of adenosine diphosphate, such as would be expected to result from mixing of any adenosine diphosphate formed during the tetanus with that initially present in the resting muscle.

The present experiments were designed to produce an even more crucial test of the postulate, by studying

Table 1. SPECIFIC ACTIVITIES OF PHOSPHORUS COMPOUNDS OF MUSCLE AFTER INJECTION OF IRRADIATED PHOSPHATE.
Stimulated muscle: at rate of three twitches per sec. for 1 hr., beginning 5 min. after intravenous injection of tracer. Results in terms of c.p.m. per mgm. phosphorus, calculated to basis of 10^6 c.p.m. injected per kgm. body-weight

Phosphorus fraction	Experiment 1		Experiment 2	
	Resting	Stimulated	Resting	Stimulated
Orthophosphate	312	263	595	460
Phosphocreatine	57	69	169	101
Terminal phosphorus of adenosine diphosphate	45	59	64	54
Terminal phosphorus of adenosine triphosphate	115	111	124	84
Middle phosphorus of adenosine triphosphate	63	71	77	68

the effect of a prolonged series of single twitches on any possible redistribution of isotopic phosphorus between these compounds. The gastrocnemius muscles of cats under pentobarbital anæsthesia were dissected free at their insertions, tracer phosphate was injected intravenously, and one muscle was attached to a lever and placed under tension. 5 min. were allowed for distribution of the tracer into the extracellular phase. The one muscle was then stimulated through the nerve at the rate of 3 twitches per sec. for 1 hr. This muscle and the companion resting muscle were then frozen *in situ* with a mixture of dry ice and ether. The various phosphorus compounds were isolated from trichloracetic acid filtrates by the ion exchange procedures used previously[5]. The terminal phosphorus of adenosine triphosphate was isolated by the action of myosin–adenosine triphosphatase, the phosphorus of the middle group of adenosine triphosphate, the terminal one of adenosine diphosphate, and of phosphocreatine were isolated by appropriate acid hydrolysis, and measurements of radioactivity made by the methods of the previous study. The samples were counted for a sufficient length of time to reduce the statistical error to less than 2 per cent.

The results of two representative experiments are given in Table 1. It can be seen that there is no significantly greater approach to isotopic equilibrium between these various phosphate groups in the stimulated muscles than in the resting ones, despite the more than 10,000 contractions and relaxations undergone by one muscle of each pair. Also, it appears that there is no increase in the total amount of phosphate transported across the cell membrane of the muscle during this rather intense and prolonged activity. The experiments in Table 1 have been selected from a larger number, all of which show the same general picture. In some, the range of specific activities is higher on the side of the stimulated muscle; in others, on the side of the resting muscle. The variations found between the two muscles of a single experiment are of the same order as was found between companion resting muscles, 1 or 2 hr. after the injection of the tracer[5].

These results, added to those from other types of experiments on surviving muscle, should make it evident that the participation of adenosine triphosphate in the mechanical event, which has been adduced from experiments on glycerinated fibres and actomyosin filaments, does not involve any dephosphorylation of the compound. Consequently, the source of the energy for the contraction process must be sought elsewhere than in the dephosphorylation of adenosine triphosphate.

This work was supported by a grant from the National Institutes of Health and by a contract between the U.S. Atomic Energy Commission and the University of Arkansas.

JACOB SACKS

Department of Chemistry,
University of Arkansas,
Fayetteville. Dec. 29.

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Excitation–Contraction Coupling in Heart Muscle

THERE is general agreement that the membrane process activates the contractile mechanism in muscle; but up to the present all efforts to find quantitative relations between the electrical and mechanical parameters have failed.

Experiments, hitherto performed on this field, have compared the action-potential with the time-parameters or the amplitude of contraction. However, since the analysis of the mechanical properties in striated muscle[1-3] has shown that the time-course of contraction is the result of several events, it seems reasonable to suppose that only one of these may be correlated to the electrical changes on the side of the membrane.

In agreement with previous findings, our experiments have led to the conclusion that the mechanical shortening, induced by activation of the membrane, depends, in a well-defined manner, on the length of muscle. Hence, the question arises how long and to what extent this dependence is maintained in any instant during a contraction-cycle. For this reason, in several series of experiments, strips of frog and turtle ventricle and auricle have been released quickly in the resting state and during the rising and falling phase of contraction[4]. The following results were obtained.

The increase of the active recovery-peak tension after release, if corrected for the change in tension due to the elasticity of the series compliance (so-called *Aktivierung*), declines during the contraction-cycle. The time course of the *Aktivierung* has a characteristic shape in different muscles: in the ventricle a relatively long-lasting plateau during the rising phase of contraction, with a subsequent steep decline during relaxation, is observed, whereas the auricle shows a rather short plateau followed by a flat decline of the *Aktivierung*. The skeletal muscle is characterized by the absence of a plateau, and an instantaneous decline of the *Aktivierung* after the latent period.

Because of the striking similarity of the time-course of the *Aktivierung* with that of the action-potential in all preparations investigated we have studied the time-course of both *Aktivierung* and action-potential, the latter by a routine extracellular method[5].

In Figs. 1 and 2 the time-course of the *Aktivierung* and the repolarization phase of the action-potential is given for a frog ventricular strip (Fig. 1) and a turtle auricular strip (Fig. 2). The zero point of the diagrams is the beginning of the rising phase of the isometric contraction. The electrogram is shifted towards the same zero point, so that the electro-

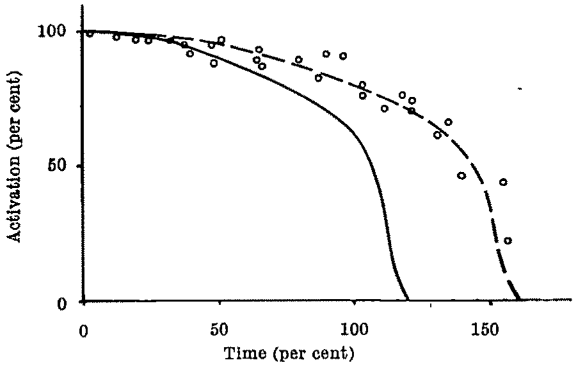

Fig. 1. Ventricular strip of frog (*R. esculenta*); temperature, 2·5° C.; length, l_0 = 10 mm.; weight, 50 mgm.; electrical stimulation frequency, 5·5/min. Resting tension before release, 2·0 gm.; peak tension, 7·5 gm. Release = 0·24 mm. ≑ 2·4 per cent l_0; duration of release, 0·019 sec.; peak time of isometric contraction, 3·6 sec. Open circles, time course of *Aktivierung* (100 per cent = full *Aktivierung*) obtained by release before the stimulus; solid line, repolarization phase of extracellular action-potential; 100 per cent = peak potential; dotted line, action-potential with enlarged time-scale (factor 1·4). Zero point of the *Aktivierung*: beginning of the rising phase of isometric contraction. Zero point of the electrogram shifted toward the same instant. The rising phase of the action-potential is neglected. Time scale, 100 per cent = peak time of contraction

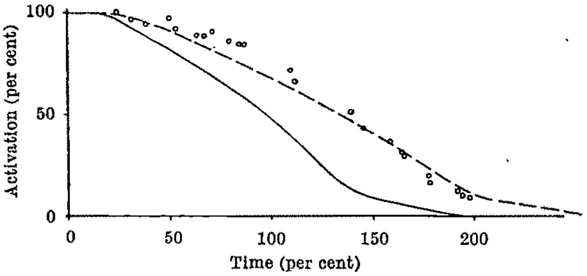

Fig. 2. Auricular strip of turtle (*Testudo graeca*); temperature, 9° C.; length, l_0 = 20 mm.; weight, 150 mgm.; electrical stimulation frequency, 8·6/min. Resting tension before release, 9·0 gm.; peak tension, 27·0 gm. Release = 0·48 mm. = 2·45 per cent l_0; duration of release, 0·016 sec.; peak time of isometric contraction, 1·5 sec. Further details as for Fig. 1

mechanical latency is neglected. For practical reasons, the rising phase of the action-potential is not considered in the diagram. In both preparations, the rate of repolarization is greater than the decline of the *Aktivierung*. However, if the time-scale of the action-potential is enlarged by a factor 1·4, both curves coincide.

The same result was obtained in 20 experiments in a range of temperature of 0–10° C. and of rate of stimulus of 2·5–10/min. The change in temperature and stimulus frequency has the same effect on both curves (Fig. 3). The time factor may vary in different experiments from 1·1 to 2·2, the mode being 1·4. A simple explanation of this change in time-scale results from the fact that the time-course of the extracellular action-potential is quickened, if led off in Ringer solution, in comparison with that recorded in air[6]. We conclude from our findings that the action-potential governs the contractile process via the rate of *Aktivierung* in any instant. How the normal time-course of contraction is correlated with the mechanical event of *Aktivierung* is still an open question.

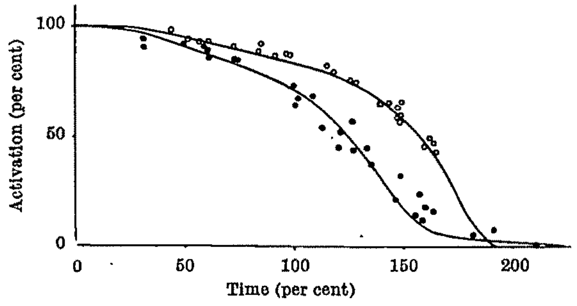

Fig. 3. Ventricular strip of frog (*R. esculenta*). Weight, 60 mgm.; length, 8 mm.; release = 0·27 mm. = 3·4 per cent l_0. Open circles, temperature, 10° C.; stimulus frequency, 12/min.; closed circles: temperature, 2·5° C.; stimulus frequency, 6/min.; solid lines: corresponding repolarization curves

H. Reichel
A. Bleichert

Physiologisches Institut,
University of Munich.
Dec. 11.

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Oxygen Equilibrium of Human Hæmoglobin in Strong Salt Solutions

It has been reported by several authors that human hæmoglobin dissociates into sub-units in strong salt solutions (that is, in sodium chloride above 0·5 *M*). The decrease of molecular weight of hæmoglobin in such conditions was demonstrated by sedimentation[1,2], osmotic-pressure[3] and light-scattering[4] methods. According to present views[5] on the oxygen equilibrium of mammalian hæmoglobins, the decrease in the molecular weight of hæmoglobin (and therefore the decrease in the number of the oxygen-combining centres per molecule) should be accompanied by alterations of the shape of the oxygen equilibrium curve. Taking the value of n in the Hill empirical equation:

$$Y = \frac{K(pO_2)^n}{1 + K(pO_2)^n}$$

as a measure of the sigmoid character of the curve, this value should be lower than 2 for a splitting of hæmoglobin into halves[5].

While investigating the mechanisms involved in the oxygen equilibrium of hæmoglobin, it seemed, therefore, interesting to study the effect of high salt concentrations on the oxygen dissociation curves of human hæmoglobin.

The oxygen dissociation curves were determined by the spectrophotometric method previously described[6]. Human hæmoglobin was prepared from freshly drawn blood; the erythrocytes were washed several times with 1 per cent sodium chloride solution and finally hæmolysed with water. The hæmoglobin solution was centrifuged at 20,000 r.p.m. for 30 min. and then dialysed for 48 hr. against de-ionized water.

The oxygen equilibrium of human hæmoglobin in the presence of 0·3 *M* phosphate buffer alone and plus added salts, at pH 7 and 20° C., is given in Table 1 and Fig. 1. The results demonstrate that in high salt concentrations even for dilute hæmoglobin solutions, the oxygen equilibrium curves do not show a decrease but rather an increase in the value of n. Indeed, in conditions in which the hæmoglobin molecule should be split into halves the value of n was near or greater than 3. In strong salt solutions an

Table 1. Oxygen Equilibrium of Human Hæmoglobin in Strong Salt Solutions

Salt added	Final molarity of the salt added	log $p\frac{1}{2}$	n
None	—	1·04	2·9
None	—	1·08	2·9
Potassium chloride	2	1·18	3·0
Potassium chloride (After 24 hr.)	2	1·14	2·9
Potassium chloride	1	1·15	2·9
Potassium chloride	0·5	1·12	2·9
Sodium chloride	2	1·11	2·95
Tris-hydrochloric acid	2	0·92	3·0
Sodium sulphate	1	1·07	3·0
Sodium citrate	1	1·05	3·05
Potassium dihydrogen phosphate-dipotassium hydrogen phosphate	1	1·03	3·1

Hæmoglobin $2 \cdot 5 \times 10^{-4}$ *M* (as iron); *p*H 7; 20° C.; potassium dihydrogen phosphate–dipotassium hydrogen phosphate buffer 0·3 *M*. $p\frac{1}{2}$ = oxygen pressure in mm. mercury for 50 per cent oxygen saturation. The value of n (in the Hill empirical equation) was calculated by the slope of the curve of log $\frac{(HbO_2)}{(Hb)}$ versus log p, near 50 per cent saturation. The salt and the buffer were usually added 30 min. before the experiments.

apparent discrepancy can be seen between the shape of the oxygen equilibrium curve and the estimated number of hæms per molecule. This finding seems to be of importance to the interpretation of the oxygen equilibrium of hæmoglobin.

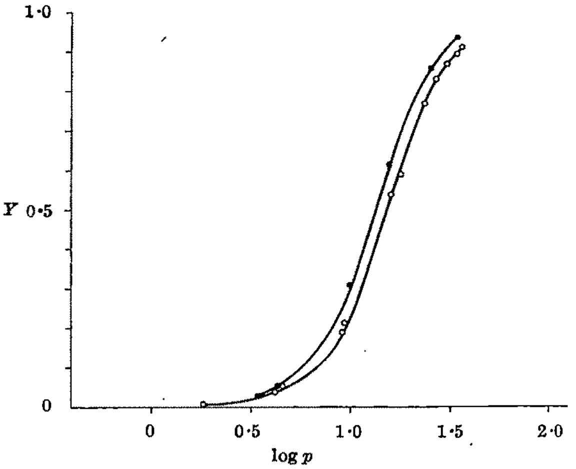

Fig. 1. Oxygen equilibrium curves of human hæmoglobin in 0·3 *M* phosphate + 2 *M* sodium chloride (●) and in 0·3 *M* phosphate + 2 *M* potassium chloride (○). *p*H 7, 20° C. hæmoglobin $2 \cdot 5 \times 10^{-4}$ *M* (as iron)

A more detailed study of the effect of salts on the functional and molecular properties of human hæmoglobin will be reported elsewhere.

A. Rossi-Fanelli
E. Antonini
A. Caputo
Institute of Biological Chemistry,
University of Rome,
and 'Regina Elena' Institute of Cancer Research,
Rome.

Dec. 31.

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A Possible Vitamin E Deficiency occurring in a Herd of Pigs fed Standard Rations in the Tropics

At the Sigatoka Agricultural Station in the Fiji Islands, it had been noted that an occasional baby piglet was born exhibiting symptoms of muscular weakness and inco-ordination in one or more legs. These piglets were born in litters from both pure and cross-bred sows and gilts of the Tamworth, Berkshire and Large White breeds.

As the clinical symptoms were somewhat similar to those described by workers in the temperate zone as occurring in lambs suffering from 'stiff lamb disease' and calves with 'white muscle disease' (Blaxter and Brown[1]), and in piglets born to sows fed on a vitamin E deficient ration (Adamstone *et al.*[2]), it was decided to test the effect of the administration of synthetic vitamin E. In late 1954 two piglets that were particularly severely affected were drenched with 50 mgm. of vitamin E at two days of age. They both effected a dramatic recovery, all clinical symptoms of the condition disappearing within 48 hours of treatment.

This suggested that the symptoms of muscular weakness exhibited by piglets might be due to a vitamin E deficiency in the sows: a very surprising conclusion, as the breeding stock in the station herd were managed in a normal manner in concrete sties and were fed on rations consisting of:

Coconut meal	40 or 45 parts	Molasses	10 or 20 parts
Rice bran	40 or 30 parts	Meat meal	10 or 5 parts

together with a mineral mix and adequate green feed. It is usually considered that a ration of this type contains sufficient vitamin E to meet the normal requirements of farm animals in almost any circumstance. Unfortunately, it was not possible to analyse the rations for vitamin E content.

In order to test the assumption that for some reason the sows might be deficient in vitamin E, all breeding stock due to farrow during 1955 and 1956 were divided at random into two groups. One group received 250 or 500 mgm. of synthetic vitamin E in one massive dose three weeks prior to the expected date of farrowing, while the other group were untreated and acted as a control. Management and feeding of the two groups were identical.

Details of the number of live and stillbirths and of the number of piglets exhibiting the clinical symptoms of muscular weakness were recorded for two years. The results are given in Table 1.

In March 1956 a female piglet born in the control group, and exhibiting symptoms of muscular weakness, was removed from the litter at two days of age and killed, and histological specimens were prepared from the lung, kidney, heart muscle, thigh muscle, shoulder muscle, tongue, abdomen, spleen, liver, brain, suprarenals, uterus, brachial plexus and sciatic nerve.

Table 1. Number of Piglets Born Alive, Still-born and Exhibiting Clinical Symptoms of Muscular Weakness during 1955 and 1956

Group	No. of litters	No. born alive: Total	Per litter	No. still-births: Total	Per litter	No. with muscular weakness
Control	27	228	8·44±0·50	17	0·63±0·03	6
Vitamin E supplemented	27	246	9·11±0·65	8	0·30±0·14	0

These specimens were examined during 1957 at Cornell University by Dr. Peter Olaffson, who failed to find any indication that the piglet may have had muscular dystrophy lesions.

Thus results to date indicate that vitamin E supplementation of sows and gilts in Fiji, receiving what would be considered a normal farm ration, apparently eliminated the birth of piglets exhibiting clinical symptoms of muscular weakness, and in addition decreased the number of still-births per litter and increased the number of piglets born alive, though these effects were not quite statistically significant. Also the addition of vitamin E to the diet of two baby piglets exhibiting the muscular weakness resulted in their dramatic recovery. Histological examination of tissues from one affected piglet failed to disclose any signs of muscular dystrophy lesions.

It is considered that the balance of evidence is in favour of the theory that there was some form of vitamin E deficiency in the breeding stock. So far as is known, no one has previously reported symptoms of vitamin E deficiency in a herd of pigs fed standard type rations, though Gorham *et al.*[3] and Davis and Gorham[4] have reported a condition known as 'yellow fat' disease in pigs fed on a rather unusual ration of fish scraps, which responded to vitamin E supplementation of the ration, and which is probably caused by excessive amounts of unsaturated fatty acids in the diet. Obel[5] has also reported that death from liver dystrophy is high in pigs in Sweden aged 3–15 weeks, where 6 per cent of cod-liver oil is fed in the ration, and that this disease is prevented by substituting lard for cod-liver oil and supplementing the ration with vitamin E.

The rations fed to the pigs in Fiji contained a high proportion of coconut meal which was usually slightly rancid. As the oxidation of vitamin E is especially rapid in foods containing high levels of unsaturated fatty acids or rancid fats together with minerals that catalyse the oxidative reactions, it is possible to postulate that the available vitamin E in the ration was being oxidized. This theory is supported by a report from Jamaica by McDonnough[6], who states that two calves fed on irrigated grass with a concentrate supplement of coconut meal that may have been rancid died, the post-mortem examination revealing that they were suffering from 'white muscle disease'. It is hoped to investigate this theory further at this establishment.

I am indebted to the Director of Agriculture, Fiji, for providing facilities for this work and for permission to publish it, to Dr. Peter Olaffson, of Cornell University, for the histological examinations, and to Mr. R. K. Naidu for the completion of the experiment while I was on leave.

W. J. A. Payne

East African Agriculture and
Forestry Research Organization,
P.O. Box 21,
Kikuyu,
Kenya.
Jan. 2.

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Cardiac Output in Cattle

The determination of cardiac output by the dye dilution techniques requires the taking of serial arterial blood samples at short regular intervals. Direct puncture of the brachial artery of cattle[1] enables such samples to be collected. *T*.1824 (Evans blue) was injected into the jugular vein of the subjects at a dose of approximately 0·40 mgm./kgm. body-weight and arterial blood samples collected at 1-sec. intervals for a period of 30 sec. Adopting the procedure described by Hamilton *et al.*[2] the average concentration of the dye in the arterial blood samples was found, together with the time required for one circulation of the dye and the cardiac output calculated from the formula:

$$\text{cardiac output} = \frac{60 \times \text{amount } T.1824 \text{ injected}}{\text{mean concentration } T.1824 \times \text{circulation time}}$$

The subjects were allowed to settle in their surroundings for some time prior to making a determination, and during the manipulative procedures excitement of the subjects was avoided so far as possible. Pulse-rates were taken during injection of the dye and collection of arterial blood samples; and during the procedure on each animal the pulse-rate remained within the normal range of 65–90 beats per min.

Twenty-six cardiac output determinations were made on 22 female Ayrshire cattle of body-weight 100–605 kgm. The outputs ranged from 12 to 68 l. of blood per min. which, when calculated as output of blood in ml./kgm. body-weight per min., give a mean value of 113 ml. with an *S.D.* ± 11·0 ml.

The result calculated for cattle as cardiac output of blood in ml./kgm./min. is similar to that obtained in sheep by Schambye[3] using a dye-dilution technique and by Cross *et al.*[4] using the Fick method. It also compares with the value obtained by Barcroft *et al.*[5] using the Fick method on goats. Doyle *et al.*[6] used the Fick method on three adult cows to determine the cardiac output and found a mean value of 44 l./min. but made no mention of the breed or weight of the animals.

Edward W. Fisher
Rodger G. Dalton*

University of Glasgow Veterinary School,
Veterinary Hospital, Bearsden Road,
Bearsden, Glasgow.
Jan. 6.

* Agricultural Research Council Research Student.

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Production of Acute Insulin Deficiency by Administration of Insulin Antiserum

The diabetic syndromes observed in experimental animals and in man are due to metabolic abnormalities induced directly or indirectly by insulin deficiency and to lesions which affect tissues other than the β-cells of the islets of Langerhans. It is difficult to

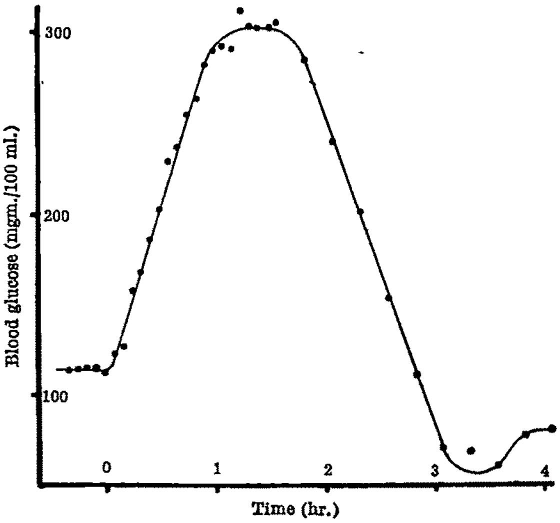

Fig. 1. Concentration of glucose in the blood of a conscious female rabbit (2·65 kgm.) following the intravenous injection at zero time of serum (2·7 ml.) from guinea pigs sensitized to bovine insulin

attribute the pathological effects observed in these syndromes to specific lesions since the methods at present available do not render animals rapidly and reversibly insulin-deficient without provoking other complicating effects.

Such a method has now been devised and is based on observations originally published by Moloney and Coval[1]. They showed that serum from guinea pigs sensitized to insulin (insulin antiserum) protects mice from the convulsive action of the hormone. It also induces hyperglycæmia 1 hr. after injection into mice and produces a diabetic syndrome with ketonuria and loss of body-weight if the injections are repeated for 3 days. It was then found[2] that the stimulant action of insulin upon the isolated rat diaphragm can be abolished if such serum is added to the incubation medium. These effects are thought to be due to the presence in the serum of antibodies which are specific but not species-specific for insulin.

In the present investigations, intravascular injection of a single dose (1·0 ml./kgm.) of serum from guinea pigs sensitized to bovine insulin has been shown to produce an immediate rise in the concentration of glucose in the blood of the anæsthetized (nembutal) or conscious rabbit. This rise, which is detectable within 5 min. of the injection, continues at a uniformly rapid rate for 30–50 min. The glucose concentration reaches a maximum (200–300 mgm./100 ml.) in 1–2 hr., and returns to the resting-level (80–110 mgm./100 ml.) in 3–5 hr.; the result obtained in a typical experiment is shown in Fig. 1. The effect produced by a slightly larger dose (2 ml./kgm.) injected into the rat is more transient, the hyperglycæmia being maximum in 30–60 min. and complete in 60–90 min. Normal guinea pig serum has no such effects on injection into rabbits or rats.

Using a technique previously described[3] it was found that plasma obtained from hyperglycæmic rabbits 1 hr. after injection of the insulin antiserum does not stimulate glucose consumption by the isolated rat diaphragm. It was concluded, therefore, that insulin, the effects of which were detected in rabbit plasma prior to injection of the insulin antiserum, had been neutralized and that the hyperglycæmia was due to absence of circulating insulin. The rabbits used in these experiments had one ear chronically denervated and the vessels of these denervated ears remained dilated throughout; endogenous adrenaline secretion was not, therefore, responsible for the hyperglycæmia. The glucose entering the blood-stream is probably derived from the liver, for whereas a marked rise in blood glucose concentration follows injection of insulin antiserum into the fed rat, only a small and gradual rise occurs if the store of liver glycogen is first depleted by fasting for 24 hr.

Assuming that the extracellular space occupies 20 per cent of the body-weight, it can be deduced from the results of the present experiments that during the initial stages of the hyperglycæmia glucose enters this space at the rate of approximately 1 mgm./min./100 gm. body-weight. This figure, which probably represents the rate at which glucose is consumed by tissues under the influence of circulating insulin, is of the same order as the glucose turnover-rates determined previously in normal rats and dogs by means of injections of glucose labelled with carbon-14 [4–6]. The rapid and transient action of this insulin antiserum suggests that endogenously secreted insulin exerts its effects rapidly and that these effects are of brief duration.

By contrast the methods currently used to produce diabetes in laboratory mammals[7,8] are often technically difficult. The syndromes are all characterized by injury, destruction or removal of the insulin-secreting cells of the pancreas, but in addition the syndrome due to insulin deficiency is complicated by the effects of other lesions; after pancreatectomy or treatment with alloxan, for example, structures other than the β-cells of the islets of Langerhans are removed or damaged. In most cases the diabetic state is not reversible, and the animals have to be maintained by parenteral insulin therapy. Withdrawal of insulin in such cases does result in the development of the diabetic syndrome, but the rate at which this occurs depends upon the nature of the insulin preparation used and at best only a gradual rise in the concentration of blood glucose is observed over a period of hours. The method described above has the great advantage that it produces hyperglycæmia rapidly and is technically simple. In addition, the hyperglycæmia is reversible, is due to insulin deficiency, and cannot be attributed to any non-specific effect of the proteins in guinea pig serum.

A more detailed account of these investigations, which are being carried out in co-operation with Dr. R. T. Grant and Mr. J. Armin, will be published elsewhere.

P. H. WRIGHT

Department of Chemical Pathology,
Guy's Hospital Medical School,
London, S.E.1.

Jan. 8.

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RADIOBIOLOGY

Changes in the Electron Spin Resonance Spectrum of Glycine with Increasing Doses of Radiation

It has been reported[1] that paramagnetic centres are produced in glycine by equal doses of γ-rays, fast neutrons and α-particles in the proportions 1 : 0·7 : 0·1. As the lower efficiency of the α-particles might well be due to the high linear energy transfer along their tracks, an investigation of the effects of very high doses of electrons on the electron spin resonance spectrum of glycine and related substances seemed worth while.

For irradiations we used a 1·5-MeV. Metropolitan-Vickers linear accelerator capable of delivering approximately 10^4 rads per pulse at the position of the sample of deoxyribonucleic acid, the duration of a single pulse being 2 μsec. Derivatives of the microwave absorption against magnetic field strength were recorded. The electron spin resonance spectrometer used for this work operates on 9,350 Mc./s. and utilizes heterodyne detection of an audio-modulated signal.

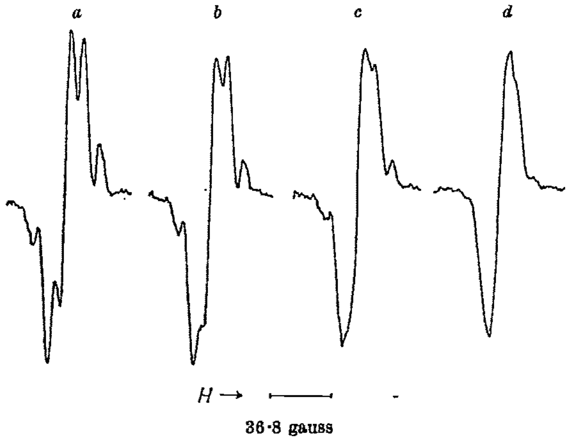

Fig. 1. Derivative of absorption signal of glycine, irradiated in air with *a*, 20 Mrads ; *b*, 50 Mrads ; *c*, 100 Mrads ; *d*, 200 Mrads

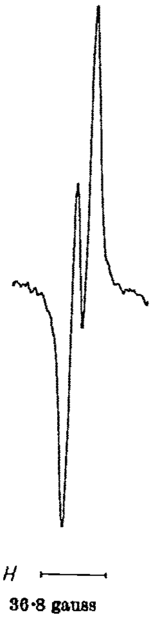

Fig. 2. Derivative of absorption signal of gelatine irradiated in air with 20 Mrads

In glycine which has received a dose of 20 Mrads the differential curve shown in Fig. 1*a* is obtained, displaying five peaks, whereas with still lower doses of the order of kilorads, triplets have been observed[2].

Increasing the dosage from 20 Mrads to 200 Mrads changes the shape of the absorption curve in a manner shown in Fig. 1*a*–*d* until only a broad single peak is left.

In gelatine, however, as in other substances containing glycine as glycylglycine[3], a double peak shown in Fig. 2 is obtained, which does not change in the same range of doses. The paramagnetic centre which causes this double peak may be identical with that which causes the two large side peaks in glycine. The central peak, on the other hand, may be due to a different centre, which is produced more efficiently at high doses. The two side-peaks would in this way vanish progressively in relation to the central peak.

One of us (A. M.) is indebted to Dr. L. H. Gray for his hospitality and to the Institute of Radiobiology, Reactor Station, Karlsruhe, for a travel grant.

J. W. Boag
A. Müller

Research Unit in Radiobiology,
Mount Vernon Hospital,
Northwood, Middx. Jan. 29.

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Electron Spin Resonance in Irradiated Deoxyribonucleic Acid

Radiation-induced electron spin resonance in deoxyribonucleic acid has already been briefly reported[1]. We have studied the electron spin resonance spectra of samples of deoxyribonucleic acid irradiated *in vacuo*, in air and in nitric oxide. These gases are known to affect electron spin resonance signals[2,3] and to influence biological effects of radiation[4,5].

The deoxyribonucleic acid was kindly provided by Prof. J. A. V. Butler. It had been prepared from calf thymus and contained 0·7 per cent by weight of protein and, when exposed to room air, some 15 per cent of water. Pulses of electrons from a 1·5-MeV. Metropolitan-Vickers linear accelerator were used for irradiating the samples, the pulse duration being 2 μsec. and the dose per pulse about 10^4 rads. Total doses up to 10^8 rad were given in some experiments. The electron spin resonance spectrometer operated at 9,350 Mc./s. and employed heterodyne detection of an audiomodulated signal. First derivatives of the absorption curves were recorded.

The samples were placed in thin-walled glass tubes in which they could be kept under vacuum before, during and after the irradiation. They were irradiated in one part of the tube and then slid along to the unirradiated end before testing in the electron spin resonance spectrometer. The high doses were given in many short bursts, separated by long enough intervals to prevent overheating of the material.

If the samples were dried *in vacuo* for 24 hr. prior to irradiation and were then irradiated either *in vacuo* or in the presence of dry air or nitric oxide a good

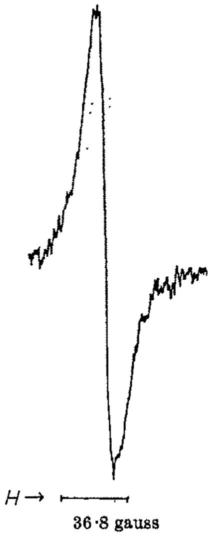

Fig. 1

electron spin resonance signal was observed in all cases. An example is shown in Fig. 1. If the sample was kept in a dry atmosphere, the signal did not decrease appreciably in a week. The decay of resonances reported by other workers[6] may have been due to the presence of moisture in the gases used, an effect which has been observed in some biological materials[7]. When moisture was present in our experiments at the time of irradiation, however, we were unable to detect any electron spin resonance signal even with a dose of 10^8 rads.

We are indebted to Prof. J. A. V. Butler for the samples of deoxyribonucleic acid used and to Dr. L. H. Gray for his encouragement and for many useful discussions.

J. W. Boag
A. Müller

Research Unit in Radiobiology,
Mount Vernon Hospital,
Northwood, Middx. Jan. 29.

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Protective Effect of β-Aminoethylthiosulphuric Acid against Ionizing Radiation

It was recently demonstrated that thiosulphate esters rapidly react with protein sulphydryl groups to give mixed disulphides[1]. As Eldjarn and Pihl[2] have attributed the protective properties against radiation of certain sulphur compounds (for example, cysteamine, cystamine) to their ability to form mixed disulphides with active sulphydryl or disulphide groups in the cell, the possibility was considered that thiosulphate esters may be active protectors against ionizing radiation.

This has now been verified with β-aminoethylthiosulphuric acid[3], and the protecting effect of this compound has been compared with that given by cysteamine. The acute toxicity of β-aminoethylthiosulphuric acid (determined as *LD*50 by intraperitoneal injection into 50 albino mice according to Miller and Tainter[4]) was found to be 0·90 ± 0·02 gm./kgm. body-weight, whereas the *LD*50 of cysteamine hydrochloride determined by the same technique was obtained as 0·50 ± 0·01 gm./kgm. body-weight. Cysteamine hydrochloride is then about 2·4 times as toxic as β-aminoethylthiosulphuric acid, calculated on an equimolar basis.

The protective effect of β-aminoethylthiosulphuric acid on mice, irradiated with a lethal dose of X-rays, as compared with that of cysteamine hydrochloride, is shown in Fig. 1 (each compound was injected at a dose corresponding to 0·5 *LD*50). It is evident that β-aminoethylthiosulphuric acid increases both the time and rate of survival, although the latter showed a smaller increase than in mice injected with cysteamine. The possibility that the protection given by β-aminoethylthiosulphuric acid is due to cystamine or cysteamine, formed from β-aminoethylthiosulphuric acid in the body, cannot be excluded, but appears unlikely from previous *in vitro* studies on β-aminoethylthiosulphuric acid[1].

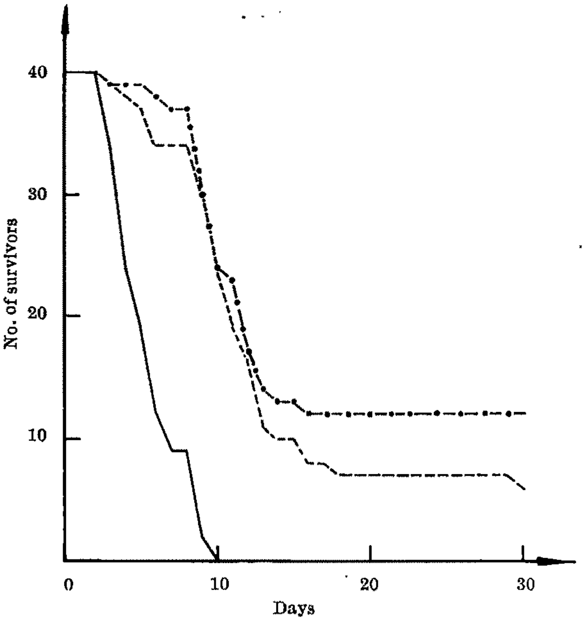

Fig. 1. Protective effect of β-aminoethylthiosulphuric acid and cysteamine against X-rays. Male albino mice exposed to 1,000 r. Protective compounds injected intraperitoneally 15 min. before irradiation. Without protector, ———; β-aminoethylthiosulphuric acid, 0·45 gm./kgm. body-weight, – – – – – –; cysteamine hydrochloride, 0·25 gm./kgm. body-weight, –.–.–.–

Bo Holmberg
Bo Sörbo

Research Institute of National Defence,
Medical Department,
Sundbyberg, 4,
Sweden. Dec. 15.

[1] Sörbo, B., *Acta Chem. Scand.*, **12**, 1990 (1958).

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Leucocytosis in Response to Bacteræmia as a Feature of the Acute Radiation Syndrome in the Plaice

Bacterial invasion of the blood-stream is a marked feature of the acute radiation syndrome in the mammal following exposure to mid-lethal and supra-lethal doses of ionizing radiation[1-6]. It is generally considered that the bacteria are enteric in origin and that they gain access to the blood-stream through failure of the host defence mechanism, following the radiation insult, that is, ulceration of the gastro-intestinal tract, and leucopænia[1,7]. According to Bennett *et al.*[3] death attributable to such infection of the blood-stream in dogs is always associated with leucopænia, and Cronkite and Brecher[6] consider that the body of evidence available appears to establish

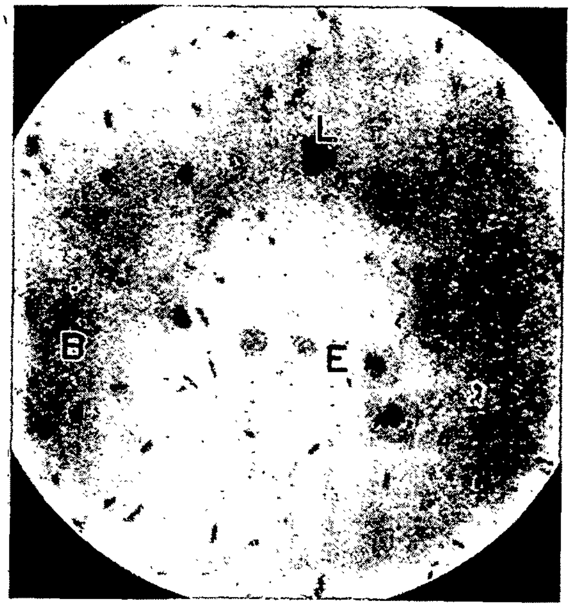

Fig. 1. Blood smear from plaice dying after exposure to 8,000 r. Note large numbers of bacilli (*B*), nucleated erythrocytes (*E*) and large numbers of leucocytes (*L*)

a firm correlation between granulocytopænia and susceptibility to infection in radiation injury.

During a series of experiments to determine the median lethal dose for plaice, exposed to 250-kV. X-rays (Morgan, F., unpublished results), bacteræmia was observed in association with leucocytosis in two fish which had received 8,000 r. (Fig. 1).

These fish died 45 and 51 days after exposure, and both were examined within a few minutes of death, blood being removed by cardiac puncture. Their relative hæmatological values are given in Table 1. The normal ratio of erythrocytes to leucocytes in the place is 40 : 1 ; in these fish the ratio was approximately 1·2 : 1, a substantial degree of leucocytosis. The anæmia revealed by the results in Table 1 is consistent with the extensive hæmorrhages that were visible in the viscera of both animals and in particular in the duodenum and small intestine, where the extravasated blood present in the lumen indicated considerable damage to the gastro-intestinal tract.

A feature of the acute radiation syndrome in cold-blooded vertebrates is the extended period between exposure and the onset of symptoms[8]. A leucopænic condition might not have been established in these fish at the time of infection, thus perhaps facilitating the response of the leucocytes to the infection. That this is unlikely is shown by the results of an autopsy carried out on a fish exposed to 2,000 r. and dying 56 days after exposure, which revealed a considerable leucopænia, with an erythrocyte to leucocyte ratio of 252 : 1. It seems probable, therefore, that the ability of plaice leucocytes to respond to bacterial invasion of the blood-stream, following exposure to acute doses of 250 kV. X-rays, may be a major difference between the development of the mammalian acute radiation syndrome and that of the plaice.

Table 1. HÆMATOLOGICAL VALUES OF THE TWO FISH EXPOSED TO 8,000 R. COMPARED WITH THOSE OF NORMAL FISH

Fish	Packed cell vol. (per cent)	Red blood count (10^6 mm.^{3})	Hb. (gm./100 ml.)
Normal	21·8	2·02	5·66
σ	3·0	0·28	0·88
8,000 r. Day 45	10·4	0·81	3·63
8,000 r. Day 51	6·5	0·49	3·22

The provision of radiation facilities by Dr. W. L. Francis, of the Norfolk and Norwich Hospital, the helpful advice of Mr. F. Morgan of this laboratory and the interest shown by Dr. R. H. Mole of the Medical Research Council Radiobiology Unit, Harwell, are gratefully acknowledged.

A. PRESTON

Ministry of Agriculture, Fisheries and Food
Fisheries Radiobiological Laboratory,
Lowestoft.
Jan. 6.

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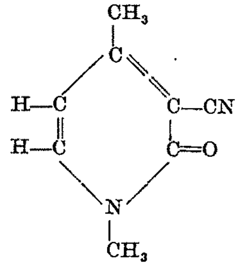
BIOLOGY

A Chromatographic Analysis for Ricinine

RICININE, the alkaloid of castor bean plants, is of interest since it is one of the very few natural products containing a nitrile group and since, as Leete and Leitz[1] have shown, it is biogenetically derived from the vitamin, nicotinic acid. In our studies on the distribution and biogenesis of ricinine we have sought a semi-quantitative analytical method that would permit routine determination of ricinine in a large number of samples of plant tissue without tedious extraction and isolation procedures. Such a goal is hindered since ricinine is neutral and does not react with the usual 'alkaloidal reagents'.



Pure ricinine was prepared from castor bean press cake by Evans's method[2]. Approximately 150 mgm. of ricinine were obtained from 1 kgm. of press cake. The characteristic ultra-violet absorption spectrum of ricinine has not been previously reported in the literature and is presented in Fig. 1. In the absence of interfering substances (for example, in the chloroform extract as obtained by Leete[1]) it would be feasible to use the absorption at 315 mμ as a quantitative measure of ricinine (*E*(1 per cent, 1 cm.) = 450). The absorption spectrum of the 2-pyridone of N-methylnicotinamide has been reported by Pullman and Colowick[3] to show a maximum at 325 mμ, somewhat higher than ricinine.

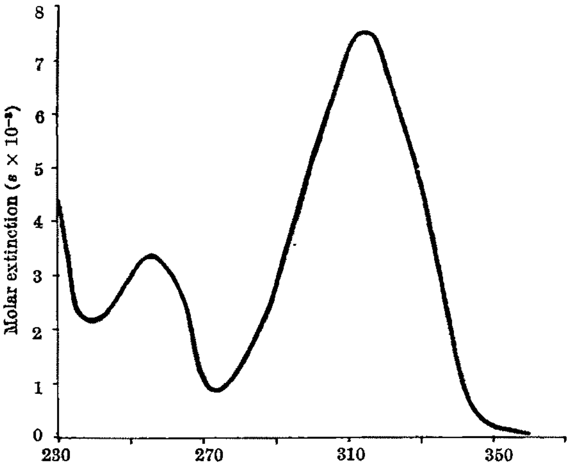


Fig. 1. Absorption spectrum of ricinine

Various solvents and spray reagents were studied for the paper chromatography of pure ricinine, using the ascending method. The most desirable solvent systems with regard to spot mobility and compactness were found to be *t*-butyl alcohol/water/acetic acid, 4 : 2 : 1, and *iso*propyl alcohol/toluene/acetic acid/water, 5 : 10 : 1 : 1, the latter being more satisfactory. The respective R_F values in these two systems were 0·75 and 0·55. The only satisfactory spray was found to be potassium tetraiodobismuthate as prepared by the method of Bregoff *et al.*[4]. This reagent gave orange spots against a yellow background. As little as 10 μgm. of ricinine could be detected, but quantitative estimation based on spot area was most successful between 20 and 100 μgm. Related compounds and possible ricinine precursors were easily distinguishable from ricinine. Nicotinonitrile and 3-hydroxyanthranilic acid gave no colour with the spray reagent though oxidative browning of the 3-hydroxyanthranilic acid spot occurred over a period of days on unsprayed chromatograms. Nicotinamide showed pink-orange coloured spots below ricinine in the latter solvent. N-methyl nicotinamide showed a pink-orange coloured spot above ricinine in the latter solvent.

The application of the above technique to plant tissues has shown remarkably little interference. It has been possible to squash small amounts of fresh tissue directly on the paper at the origin, develop with solvent, dry and spray. No spots other than ricinine have ever been observed from normal castor bean plants. Fig. 2 plots the variation in ricinine content of various organs against the total fresh weight of a plant. Because of the limited number of plants used, these results are intended merely to illustrate application of the method; however, they generally agree with the observations of Bogdashevskaya[5], who found that the percentage of ricinine in whole plants increased up to 20 days, while in individual leaves the rate of formation was greatest in the youngest leaves.

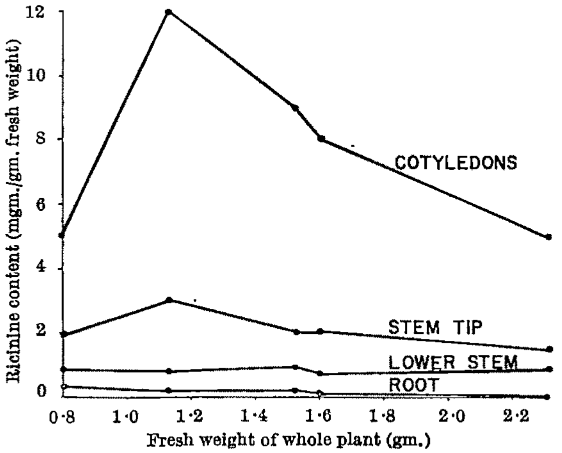


Fig. 2. Ricinine content of organs from different sizes of castor bean plants

We wish to thank the Baker Castor Oil Co., Bayonne, N.J., for supplying us with the castor bean press cake.

TREVOR ROBINSON
ELVIN FOWELL*

Department of Bacteriology and Botany,
Syracuse University,
Syracuse, New York.

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* Eli Lilly Research Fellow.

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Mitosis in the Microspore of *Encephalartos barteri* Carruth.

THE haploid chromosome number of *Encephalartos barteri*, observed at the first division of the microspore nucleus, is 9. The chromosomes are large; the largest is about 20μ long, the smallest about 10μ long. One of the longest chromosomes has a trabant (Fig. 1). The haploid number of 9 chromosomes has already been found in the six other species of the same genus which have been examined, and in species of *Zamia*, *Bowenia*, *Dioon* and *Macrozamia*[1].

Male cones of a late crop were collected in September from a plant growing in a garden in Ibadan, Nigeria. The microsporangia then contained uninucleate microspores. A cone was kept on a bench in the laboratory, and three scales were fixed each day in 1 : 3 acetic alcohol. The first pollen divisions were found after about three weeks.

The two mitoses, producing three nuclei, occur in quick succession. After the first division, the prothallial cell takes up a peripheral position while the other nucleus divides again. After the second division, in which the chromosomes are smaller than in the first, the generative cell comes to lie next the prothallial cell, which it resembles, while the tube nucleus lies centrally in the pollen grain, and remains larger and less dense than the other nuclei.

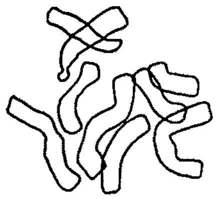

Fig. 1. The chromosomes of *E. barteri* at the first pollen mitosis; acetocarmine preparation. (× 625)

Every microsporangium contains a small percentage (about 0·1 per cent) of abnormal pollen grains. These are oval, and each apparently represents two normal grains. There is a single nucleus, and at the first mitosis there are about 18 chromosomes.

GEOFFREY K. BERRIE

University College,
Ibadan.
Dec. 15.

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Relationship between *Dictyocotyle* and *Calicotyle*

RECENTLY, the opinion has been expressed that the endoparasitic monogenetic trematode *Dictyocotyle coeliaca* is simply a cœlomic form of the common cloacal parasite *Calicotyle* which has entered, through the abdominal pores, the body cavity of certain species of *Raia*[1]. The normal posterior adhesive organ ('opisthaptor') was thought to be lost, and its central boss to regenerate a 'pseudohaptor'. The evidence given in support of this supposed ontogenetic migration was : (1) the finding, in an abdominal canal, of a trematode which had lost its opisthaptor ; (2) the recovery, from the cloaca, of six isolated opisthaptors each with a central perforation which matched the boss of the mutilated specimen.

In expressing the above opinion, Dawes and Griffiths appear to have ignored several differences between *D. coeliaca* and *C. kroyeri*[2,3]. To these previously recognized differences may be added the following. There is a characteristic difference in the shape and size of the egg capsule, as may be seen by comparing the illustrations by Hunter and Kille[2] of *D. coeliaca* and by Dawes[4] and by Euzet[5] of *C. kroyeri*. I have confirmed this difference by examining hundreds of capsules from each of the two parasites, and the difference in the egg capsules is accompanied by a corresponding difference in the size and shape of the respective ootypes. Furthermore, there is a difference in the relationship of the length of the sclerotized penis to the length of the body proper in each of the two parasites as illustrated in Fig. 1, which is based on measurements taken from a random sample of 10 cloacal and 10 cœlomic parasites from Plymouth rays[3].

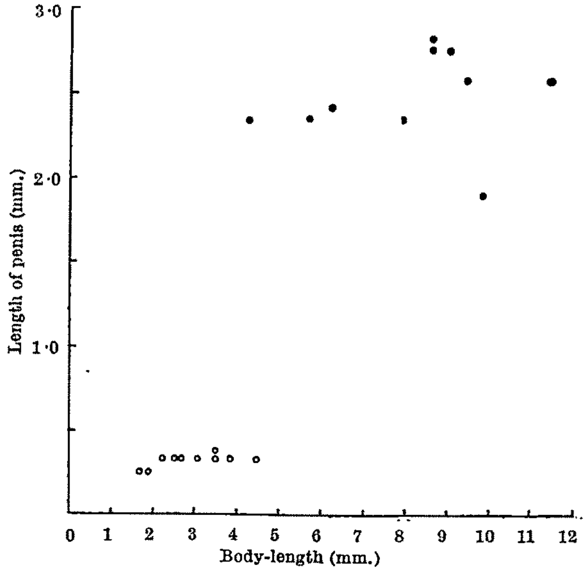

Fig. 1. Relative lengths of penis and body-proper (excluding posterior adhesive apparatus) in some monogenean parasites of *Raia* species : ●, from cœlom ; ○, from cloaca

It is conceivable that some of the differences between the cloacal and cœlomic parasites, for example, the development of diverticula from the intestinal cæca, and the lobing of the proximal region of the ovary, could possibly result from normal growth. But some other differences, for example, the re-orientation of the vaginæ and of the intestinal cæca, and the change in shape of the ootype, would involve a drastic re-organization of the body. Such a re-organization is not suggested by what is in fact known about the ontogenetic development of *D. coeliaca*. Hunter and Kille[2] have observed three young specimens (1·4, 2·2 and 2·5 mm. long respectively) in which the course of the intestinal cæca was as in the adult. Moreover, the posterior adhesive organ in these three very small specimens (compare the measurements with those given in Fig. 1), together with that in a fourth specimen only 0·57 mm. long, was of the *D. coeliaca* form, that is, having numerous shallow loculi.

C. kroyeri from the cloaca is known to produce egg capsules that yield larvæ[5]. Why then should the animal, after producing such capsules, indulge in something approaching a metamorphosis, migrate to a new ecological niche, and there produce further egg capsules ? Such a pattern of life-cycle would be, so far as I am aware, unique in the animal kingdom. Phylogenetically, the adoption by *D. coeliaca* of a habitat completely within the host could well have been by way of the abdominal canals from the cloaca to the cœlom—indeed this seems probable, and *D. coeliaca* and *C. kroyeri* are obviously closely related. Eventually it may be shown that the two species are better regarded as belonging to the same genus, but in the meantime there are no grounds for dissenting from Brinkmann's acceptance of two separate genera, a conclusion based on a thorough comparative review of six species of *Calicotyle*[6] and of *Dictyocotyle coeliaca*[7].

There is nothing in the recent observations by Dawes and Griffiths that would be inconsistent with their having found parts of damaged but otherwise normal specimens of *Calicotyle kroyeri* in the cloacas and abdominal canal of Plymouth hosts which they identified as *Raia radiata*. (The species of *Raia* at Plymouth have been studied in detail[8,9], but *R. radiata* had never been recorded previously.)

J. LLEWELLYN

Department of Zoology and Comparative Physiology,
The University, Edgbaston,
Birmingham 15. Dec. 9.

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IN giving our opinion that '*Dictyocotyle*' is simply a cœlomic form of *Calicotyle* we were well aware of some apparent structural differences between the two forms. Indeed, some of the supposedly distinctive characters had been detailed[1,2]. Perhaps the most obvious difference is one of size ; *Calicotyle* rarely exceeds 5 mm. in length, but '*Dictyocotyle*' may exceed 11 mm. It is not surprising, therefore, that the eggs of the cœlomic form should also be larger. However, the difference is not great, even in the imperfect state of our knowledge. One of us gave the size of the egg of the cœlomic form as 186μ × 100μ, with a filament 19μ long[2]; Hunter and Kille[3], who found many eggs but did not give the size-range, provided the figures 215μ × 100μ (+ 50μ for the filament). In the places cited by Llewellyn, for *Calicotyle*, comparative figures are 100μ × 110μ (+ 35μ for the filament)[4] and 100–110μ (+ 100–130μ for the filament)[5]. As regards shape, which defies description and must be greatly influenced by fixation, the eggs of the cœlomic form were said to be "pyriform"[2], "roughly spindle shaped, and triangular in cross section"[3], while those of *Calicotyle* were described as "triangular in optical section"[4], and "tétraédriques" ("deux côtés du tétraèdre sont parcourus par une lame mince formant une carène")[5]. The "three-sided pyramidal" eggs of *C. affinis* measure 145μ × 104μ (+ filament 52μ long) (no range given)[6]. Incidentally, the "carène" mentioned by Euzet is indicated in photographs of the eggs of '*Dictyocotyle*'[3]. Presumably the cœlomic form has a larger egg because of the greater size of the ootype, but we do not believe that significant differences in shape of the internal cavity of this organ, which acts as a mould in which the egg is formed, can be demonstrated for the cœlomic and cloacal forms in preserved whole mounts. As regards the cuticularized penis, the length is difficult to measure and may be less in forms acceptable to all as *C. kroyeri* than in '*Dictyocotyle*', but it definitely is not less in '*C. affinis*', where it likewise consists of three or more large turns of a spiral. Brinkmann[6] is of the opinion that '*C. affinis*' is a valid species (which is not proved beyond dispute) and a parasite of *Chimaera* which may wander from the cloaca into the rectum, but he found it also in the cloaca of *Raia fullonica*, in which location and host he also found *C. kroyeri*.

Differences in the form of the intestine and the position of the vaginal pores may be explained if we recall to mind the extreme mobility of the internal organs of the living trematode. In *Calicotyle* the presence of the opisthaptor and its extrinsic muscles provides a sort of barrier to the backward movement of the viscera. However, if the haptor is lost, such restraint is removed and the viscera will tend to 'flow' freely into a more posterior position. The same result will no doubt occur also in young forms which do not develop a normal *Calicotyle*-type haptor, the backward flow most obviously affecting the vitellaria and their ducts as well as the cæca. The hind ends of the vaginæ would also be drawn back; but their anterior ends, attached at the pores to the integument, would not be affected. The net result would be an apparently new situation of vaginal pores relative to the anterior ends of both vitellaria and cæca.

Llewellyn asks why *Calicotyle*, after producing viable eggs in the cloaca of the host, should migrate to "a new ecological niche" and there produce more eggs. We do not suggest that the trematode 'indulges' itself in any way, but merely that it passes from a precarious location into nearby abdominal canals during the course of its normal movements. Cœlomic forms presumably attain a larger size because of continued growth in a 'safer' location; cloacal forms above a certain size may be swept away, and the reason may include the fact that the opisthaptor becomes progressively relatively smaller with increase in body-size. It might be asked, however, what is the advantage of 'adopting' a habitat which is disadvantageous should the host be a male. Hunter and Kille[3] found large masses of eggs (which "showed no signs of cleavage") in the cœlom of male skates. Although able manually to squeeze eggs through the abdominal pores (the only means of egress), they had to admit "that escape through the abdominal pores is not very efficient and that the female host is mainly responsible for the transmission of the parasite"[3]. They also found eggs in the spiral valve of some of the rays examined, though it was not clear how they had reached this situation "unless they had been ingested by the host". If and when the eggs of '*Dictyocotyle*' are incubated and the emergent larvæ reared, the relationship between this form and *Calicotyle* may be fully elucidated; in the meantime, the cœlomic form remains enigmatical and we see no reason for modifying our previous opinion.

BEN DAWES

Department of Zoology,
King's College,
London, W.C.2.

IVOR GRIFFITHS

Department of Zoology,
Birkbeck College,
London, W.C.1.

Jan. 8.

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Cover on River Bottoms

IT was stated by Scott[1] that in a given area of river bottom large stones will cover a greater area of bottom than small stones (if it is assumed that all stones are equally spaced and of similar shape). The relationship between the covered bottom and size of stone is not, however, a simple linear one and it seems desirable to demonstrate this relationship.

In Fig. 1 square stones of side A are arranged at equal distances D from each other inside a square of side L, one square of side A being in the bottom left-hand corner of the enclosing square. The quantities D and L are fixed, and A varies. As A increases the sets of parallel uncovered areas will move to the right and upwards until eventually the stone in the bottom left-hand corner fills the area L^2. The bed of the river is taken to mean the continuous substratum on which the stones rest, the river bottom then being regarded as this bed together with the stones and other relatively discontinuous components resting on the bed. The area of the bed L^2 covered with the stones is denoted by C_v, and we wish to describe the behaviour of C_v as A increases.

In general we can write:

$$L = n(A + D) + x,$$

where $0 \leqslant x < A + D$, and n is a positive integer or zero.

If $A \leqslant x < A + D$, it can be seen that:

$$C_v = (n + 1)^2 A^2$$

Now increase A by a small quantity E so that:

$$L = n(A + E + D) + x', \text{ where } A + E \leqslant x'$$

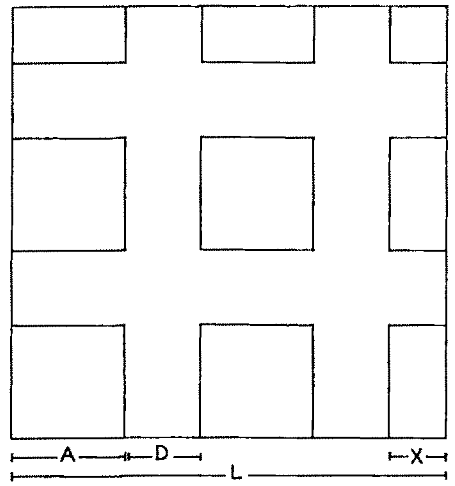

Fig. 1. The case where $0 < x < A$ and $n = 2$

Then:

$$C_v' = (n + 1)^2(A + E)^2$$

and:

$$C_v' - C_v = E(n + 1)^2(2A + E)$$

whence:

$$C_v' > C_v \text{ and so } C_v \text{ increases with } A$$

For $0 < x \leqslant A$, C_v' remains constant as A increases because the increase in C_v due to stones within L^2 is equalled by the decrease in C_v due to stones passing out of L^2. A graph of C_v against A is given in Fig. 2. The increasing portions of the curve are parabolic; but they approximate closely to the straight lines shown. A similar proof for circular stones will be developed elsewhere.

If the above theory is applied to river bottoms certain assumptions and limitations need to be considered. The assumptions of constant A and D are obviously unlikely to be met unless sorting is very efficient. Nevertheless sorting does occur, and it is possible to find areas where constant A and D are approached. It is also possible to create areas of constant A and D experimentally. It is considered, however, that the relationship demonstrated above is of less interest than the concept of C_v as a parameter in river ecology.

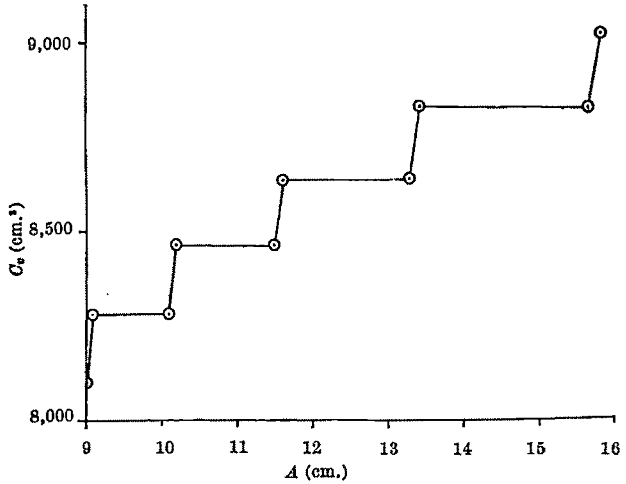

Fig. 2. The relationship between A and C when $L = 100$ cm. and $D = 1$ cm.

The importance of C_v in this respect depends on the fact that a large proportion of the macroscopic invertebrate fauna is found on the ventral faces of stones or on the bed covered by the stones[1-5]. A fraction of the fauna is also associated with the other faces of the stones, but this will not be considered here. The association of much of the fauna with what is here denoted as C_v is probably due to the fact that the stones offer areas in which there is reduced current velocity, protection from vertebrate predators, an accumulation of organic particles, and some degree of stability during floods[1]. It follows that increased size of stone will tend to be correlated with increased population density of the bottom fauna[1,6-9].

The limitations of C_v as a parameter depend on the type of river bottom examined. The usefulness of C_v will vary broadly with the proportion of smaller particles in the bed. A possible limit is offered by the Wentworth scale of clastic sediments, for the upper limit of smaller particles could be taken as 4 mm. (granules), particles below this size being regarded as small in relation to much of the invertebrate fauna. Particles above this size could be regarded as the components providing C_v. Obviously, if the bed were composed largely of boulders, and the interstices were not filled by relatively small particles, the concept of C_v could not readily be applied since cover is offered at layers below the surface of the bed. If, however, the bed consisted of sands and silt most of the fauna would utilize the C_v provided by stones resting on the bed. Another factor affecting the interpretation of C_v is the height of the stones on the bed. With increasing height of these stones, especially where D is small, the ecological difference between C_v and the uncovered bed would tend to lessen, for the screening effect of the stones would tend to bring about in the uncovered areas those factors which characterize C_v.

If these limitations are accepted, C_v can be regarded as a useful parameter. Since it is a measure of several factors that are broadly favourable to river invertebrates, it will tend to be directly related to the population density of the macroscopic bottom fauna. It can be expressed as the ratio of the sum of the areas of the larger stones in a given area to the given area. A sandbank could have $C_v = 0{\cdot}0$, while an area covered with large pieces of bedrock could have $C_v = 0{\cdot}9$.

It is accordingly proposed that the symbol C_v be used in the sense defined above. The letter C is used to denote cover, and since this letter is already used in various ways by limnologists the subscript v is added to denote current velocity.

D. SCOTT
Natural History Department,
J. M. RUSHFORTH
Mathematics Department,
Queen's College,
University of St. Andrews.

Jan. 8.

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BACTERIOLOGY

Immunological Activity of Precolostral Calf Serum

A FAILURE of passage of immune and normal antibody across the placenta of the cow has been described by a number of authors[1,2]. Antibodies have been shown to be transferred to the calf, during the first 24 hr., in the colostrum, and this has been shown to be associated with a parallel rise in serum γ-globulin from around 2 per cent of the total serum proteins to 30 per cent, the level found in the adult cow[2].

Sera from 6 calves, taken before suckling could occur, were studied to determine the basic immunological activity of a mammalian serum before the acquisition or development of normal antibodies. The sera were titrated for their bactericidal activity, and estimates were made of the titre of properdin[3] and complement. An attempt was also made to determine whether there was any conglutinin activity in these sera. Titration of bactericidal activity of the fresh sera was performed by Nagington's method[4]. Properdin was titrated by the modified method of Howard, Rowley and Wardlaw[5] and the level of conglutinating complement by that of Hole and Coombs[6].

The serum bactericidal activity of calf *R*80 is shown in Table 1. Similar activity was found with the sera of the other 5 calves. There was little or no bactericidal activity against a wide range of smooth organisms tested, whereas the serum was highly bactericidal against the two rough strains tested, *Salm. typhi SW*540 and *Shig. shiga K*624. This activity was completely removed by absorption with 0·2 gm./ml. of zymosan for 2 hr. at 4° C.

Table 1. MEAN NUMBER OF BACTERIA KILLED BY 0·02 ML. SERUM OF CALF *R*80

Smooth organisms		Rough organisms	
Salm. typhi 0901	< 1·1	*Salm. typhi SW*540	$1 \cdot 2 \times 10^5$
Salm. paratyphi A	< 2·5	*Shig. shiga K*624	$> 7 \cdot 5 \times 10^5$
Shig. shiga	1·3		
Shig. flexner 4	10		
E. coli	< 3·1		
K. pneumoniae	2·0		
Pr. vulgaris	1·4		
Ps. aeruginosa	< 4		
V. el tor	< 1·6		

The bactericidal activity was associated with a level of properdin which ranged within ± 50 per cent of the level found in a normal adult bovine serum, and with conglutinating complement titres of 16–32. No conglutinin was demonstrated by the standard method of Coombs and Coombs[7], but conglutination of starch grains (*Amaranthus cruentus*) and bacteria was observed under the phase-contrast microscope, associated with an inhibition of immune-adherence[8].

The bactericidal activity of precolostral calf serum is probably due to the interaction of properdin and complement. As antibody globulins cannot pass over the placental barrier, it is therefore probable that properdin and the components of complement necessary for the bactericidal activity of precolostral calf serum are developed by the fœtus *in utero* and are not related to the production of normal antibodies which appear to develop as a function of the age of the calf[2].

Precolostral calf serum is an example of the properdin system unaffected by normal antibody. In other systems where the bactericidal activity of properdin has been studied[9], there has always been normal antibody present which might have confused the picture. The experiment described suggests that the properdin system in the new-born calf is relatively inactive against smooth strains of bacteria, whereas it is highly bactericidal to rough strains. This is in keeping with the observation that calves deprived of colostrum are very susceptible to an *E. coli* septicæmia, despite having properdin and complement levels of the same order as those found in adult cattle.

I am indebted to Dr. A. E. Pierce of the Agricultural Research Council Institute of Animal Physiology, Babraham, for providing the six sera, and for checking their electrophoretic composition.

J. L. TURK

London School of Hygiene and Tropical Medicine,
Keppel Street,
London, W.C.1.

Jan. 8.

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A Source of Error in Microbiological Assays attributable to a Bacterial Inhibitor in Distilled Water

MOST workers in microbiological assay will have had experience of the well-established assay procedure that will occasionally give sub-optimal growth in some of the tubes, and hence discordant replicates. In our experience, folic acid assays using *Streptococcus faecalis* R are particularly prone to troubles of this kind, and such behaviour can be a serious practical difficulty.

We have observed that replication is much better in some batches of 'clean' tubes than in others and that the difference is attributable to an unidentified contaminant in certain batches of distilled water used for the final rinsing of the tubes.

'Difco' folic acid assay medium (single strength) supplemented with 2·5 mμgm. folic acid/ml. was dispensed into 'Pyrex' tubes. After autoclaving and cooling, they were inoculated with one drop of a washed, undiluted suspension of *Streptococcus faecalis* R. cells from a culture 5–8 hr. old, and growth was estimated with a 'Spekker' absorptiometer after overnight incubation. The tubes were cleaned before use by boiling for 10 min. in 2 per cent washing soda, steeping overnight in 3·5 per cent hydrochloric acid, rinsing nine times in tap water and twice in distilled water, and drying in an oven. Such tubes are designated 'clean' tubes. For the work to be described below, 'clean' tubes were filled with distilled water, autoclaved for 15 min. at 15 lb./sq. in. pressure, emptied and dried in an oven immediately before use. Such tubes are designated 'rectified' tubes.

Excellent replication could invariably be obtained if the tubes were 'rectified'; 'clean' tubes, on the other hand, would often give lower and less regular responses. Often this difference would be slight or non-existent, but in extreme instances, some of the 'clean' tubes would show no detectable growth.

Table 1

	Date of washing	3/12	10/12	11/12	17/12	18/12	19/12	20/12	24/12	31/12
'Clean' tubes	No. of tubes	10	12	12	12	12	12	12	10	10
	Mean response	0·264	< 0·109*	0·246	< 0·211*	0·326	0·330	0·458	0·270	0·322
	Coefficient of variation (per cent)	39	>108	35	>60	36	18	11	22	15
'Rectified' tubes	No. of tubes	5	6	6	6	6	6	6	—	4
	Mean response	0·457	0·501	0·497	0·457	0·450	0·450	0·499	—	0·534
	Coefficient of variation (per cent)	2·6	3·0	1·2	6·6	8·2	2·7	1·7	—	1·1

* Some tubes in these series showed negligible growth and were not read.

Batches of 'clean' tubes were compared at intervals over a period of 4 weeks in December 1957 with batches of 'rectified' tubes, and the mean growth responses, together with their coefficients of variation, are summarized in Table 1.

It will be seen that the marked irregularity both within and between batches is markedly reduced by 'rectifying'. It must be emphasized, however, that 'clean' tubes do not always behave as irregularly as in the instances quoted, and some months later, no significant difference could be detected when 'clean' and 'rectified' tubes were compared.

Many attempts were made to vary the details of the glass-washing procedure in the hope of producing the irregular results at will. All were without success until it was found that the important variable is the distilled water used for the final rinsings of the tubes. Some samples of distilled water, it is now clear, contain traces of an inhibitor, and tubes rinsed with it will support only sub-optimal and variable growth. Furthermore, the inhibitor appears to be volatile, for it is lost if the distilled water is degassed by boiling down to 50 per cent of its original volume. Table 2 shows the individual responses, means and coefficients of variation in a typical experiment, and it will be seen that tubes rinsed with degassed water would give results almost as good as those obtained by 'rectifying'.

Table 2

'Rectified' controls	'Clean' tubes			
	Rinsed with untreated distilled water		Rinsed with degassed distilled water	
0·527	0·324	0·028	0·498	0·480
0·504	0·325	0·299	0·504	0·491
0·510	0·351	0·045	0·503	0·484
0·506	0·052	0·281	0·491	0·482
0·529	0·376	0·295	0·478	0·476
Mean 0·515	0·238		0·489	
Coefficient of variation (per cent) 2·3	58		2·0	

Distilled water for glass washing in this laboratory comes from a 'strip action still' which uses steam directly from the steam mains. We have, however, examined samples of water from a 'Bara' still and from an all-glass double-distillation pyrogen-free unit, by using them for the final stages of tube rinsing. Both, on relatively rare occasions, have produced tubes inferior to the 'rectified' controls, and have been shown to be improved by degassing. The contaminant, therefore, is not peculiar to the 'strip action still', and indeed we have encountered periods of many weeks when no advantage was gained by 'rectification' and the inhibitor was, presumably, absent.

So far we have been unable to collect enough material to identify the inhibitor. We have evidence that it may be removed from the distilled water by passing through a mixed bed ion-exchange column or by activated charcoal. It can be removed from the tubes by rinsing with degassed distilled water or even with tap water, but even more successfully by rinsing with ethyl methyl ketone (other solvents have also been used successfully). The pooled ethyl methyl ketone rinsings have been evaporated to small bulk and shown to be markedly inhibitory. A preliminary examination of the residue by infra-red spectroscopy revealed peaks at 2·92, 3·43, 5·87, 7·30 and 7·96μ—a finding not inconsistent with the assumption that the inhibition is probably due to traces of short-chain fatty acids.

Toennies and Gallant[1] mentioned autoclaving in distilled water in the preparation of tubes for *S. faecalis* assays, but they did not speculate on the mechanism of this procedure. Jones[2], quoted by E. M. Lansford (private communication), found that some samples of distilled water would not inactivate biotin, whereas others, containing more than 0·1 p.p.m. of chlorine, would do so completely. Because of this, Lansford[3] degasses his distilled water for the preparation of vitamin supplements. Collier[4] has also shown that 0·3–0·4 p.p.m. chlorine might be present in distilled water. Samples of our distilled water, tested by the *o*-tolidine method, showed less than 0·05 p.p.m. free chlorine.

Wilson[5], as long ago as 1935, found that metal-distilled water had a high, but variable, bactericidal effect which was present at some times but not at others and was apparently due to metallic copper. Rinsing tubes with distilled water containing 100 p.p.m. of added copper sulphate had no effect on our experiments.

Our findings would suggest that traces of volatile inhibitors other than chlorine can occur in distilled water that can be a serious source of frustration in microbiological assays. Not only the tubes may be affected, for we have also found occasional evidence of traces of the inhibitor in other laboratory glassware; batches of medium stored therein give sub-optimal growth. Results to date would seem to indicate that a mixed bed ion-exchange column is effective in the removal of the inhibitor and there may, therefore, be an advantage in using demineralized rather than distilled water for work of this kind, as is recommended by Tomlinson[6] in the preparation of tubes for tissue culture studies.

Some preliminary experiments suggest that modification in methods of culture maintenance and inoculum production in *S. faecalis* assays may influence the sensitivity of the cells to the inhibitor. Clearly, cells that are relatively insensitive to, or media containing an antagonist for, the inhibitor will tend to give more precise assays. Our experiments suggest that *Lactobacillus fermentum* and *L. helveticus* may also be affected to a limited extent, and further experiments on these aspects are in progress.

We are grateful to Dr. E. M. Lansford, jun., for details of results obtained by Miss M. A. Jones at the University of Texas, to Mr. K. J. Stevens, who carried out some of the early experiments in this laboratory, and to Mr. P. R. Watt for examination of our sample with the infra-red spectrophotometer.

S. A. PRICE
L. GARE

Walton Oaks Experimental Station
(Laboratories of Vitamins, Ltd.),
Dorking Road,
Tadworth, Surrey.
Dec. 31.

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Application of Logarithms to the Base 2 in the Use of Exponential Dilution Series for the Study of Antibiotic Combinations

EXPONENTIAL dilution series are useful not only in serology[1,2] but also in the study of the retardation of bacterial growth caused by antibiotics in low concentrations, which may be illustrated by the following example.

Dilution series of antibiotics of concentrations c_0, $c_0.2^{-1}$, $c_0.2^{-2}$.., $c_0.2^{-x}$ are made in a fluid nutrient medium; c_0 is chosen in accordance with the activity of the antibiotic and the sensitivity of the bacterial strain investigated. Growth response after inoculation and incubation may be studied by plotting percentage absorption of light, read at regular time-intervals, against time. A set of growth-curves at more or less regular distances from each other is obtained. Interpolation, however, is difficult. Apparently, the area enclosed by a growth-curve, the time axis and the ordinates of starting- and end-points of incubation would be a good measure for the total growth-response. Having no means for continuous reading of the absorption, we have tried to approximate the response by addition of the absorption read after incubation for 2½, 5, 7½ and 24 hr. respectively. The sum, written Σa, is plotted against x, to give a concentration – response curve. Fig. 1 represents such curves for a strain of *Micrococcus pyogenes* and five antibiotics.

By means of Fig. 1 equivalent antibiotic concentrations can be determined more accurately than hitherto[3]. (We use such concentrations in the sub-bacteriostatic range in the study of antibiotic combinations.) The curves in Fig. 1 show different shapes and slopes. This feature may be difficult to explain, but it is not quite unexpected. For the time, τ, necessary to sterilize a bacterial suspension by an antiseptic, Chick[4] has given the formula $\tau = k.1/c^n$, where c is the concentration, k and n are constants, the latter characteristic of the antibiotic investigated. A similar relation may be expected between concentration and effect of antibiotics in retarding growth, and growth-response would be dependent on concentration in an inverse sense. Whatever may be the exact explanation, the consequence is that the curves in the diagram may cross one another and the ratio of the strengths of two antibiotics may thus depend on concentration. Thus, in our example it can be calculated that at $\Sigma a = 235$, 2^{-4} µgm./ml. erythromycin is equivalent to $2^{-4 \cdot 76}$ µgm./ml. novobiocin, which means that 1·7 µgm. erythromycin equals 1 µgm. novobiocin (the strain is moderately resistant to erythromycin). At $\Sigma a = 105$, however, $2^{-0 \cdot 55}$ µgm./ml. erythromycin is equivalent to 2^{-3} µgm./ml. novobiocin, so here 1 µgm. novobiocin is equalled by 5·5 µgm. erythromycin. The ratio of the relative strengths of erythromycin in both cases is 5·5 : 1·7 = 3·2 : 1. For another strain, having different sensitivities to erythromycin and novobiocin, the corresponding ratio was found to be 2·5 : 1.

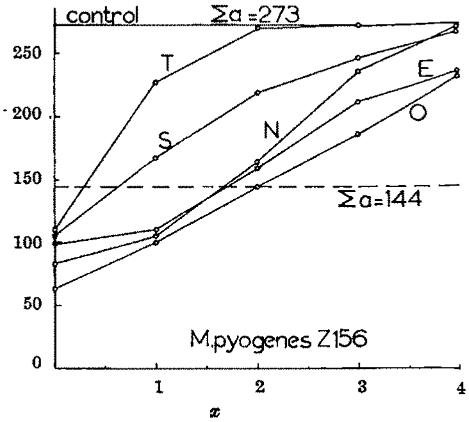

Fig. 1. Concentration–response of *M. pyogenes Z* 156 to five antibiotics. Σa = sum of percentage absorption of light by culture, read after incubation for 2½, 5, 7½ and 24 hr. in 'Bacto' heart infusion broth. Concentration: $c = c_0 \times 2{-}x$; c_x, equivalent concentrations determined for $\Sigma a = 144$.

E, erythromycin; $c_0 = 1$ µgm./ml., $c_x = 1 \times 2^{-1 \cdot 69} = 0 \cdot 31$ µgm./ml.
N, novobiocin; $c_0 = 0 \cdot 25$ µgm./ml., $c_x = 0 \cdot 25 \times 2^{-1 \cdot 66} = 0 \cdot 079$ µgm./ml.
O, oleandomycin; $c_0 = 1$ µgm./ml., $c_x = 1 \times 2^{-2 \cdot 00} = 0 \cdot 25$ µgm./ml.
S, spiramycin; $c_0 = 2$ µgm./ml., $c_x = 2 \times 2^{-0 \cdot 63} = 1 \cdot 30$ µgm./ml.
T, tetracycline; $c_0 = 40$ µgm./ml., $c_x = 40 \times 2^{-0 \cdot 92} = 35$ µgm./ml.

For our purpose concentrations at which the response amounts to about half the control value are most suitable. A reference point is chosen on the curve which best approximates linearity, in our diagram the point $x = 2$, $\Sigma a = 144$ on the curve for oleandomycin. For the other antibiotics, equivalent concentrations can now be found approximately by simple linear interpolation. This can, of course, be done directly from the numbers algebraically, which makes the laborious drawing of the diagram superfluous. The values of c_x in our example have, in fact, been calculated in this way so far as x is concerned. The calculation of $c_0.2^{-x}$ requires logarithms to the base 2. Though a special table may be used, a slide-rule with 'log–log' scales is more convenient. Sufficiently accurate for our purpose is, however, the use of a rule with cubic and $\log_{10}$ scales, since $\sqrt[3]{x}$ on the linear and x on the cubic scale correspond with $0 \cdot 1 \log_2 x$ on the $\log_{10}$ scale, which is proved by the following relation:

$$\log_{10} a = \log_2 a . \log_{10} 2$$

Therefore $\log_{10} \sqrt[3]{x} = \frac{1}{3} \log_{10} x = \frac{1}{3} . \log_{10} 2 . \log_2 x =$

$$\frac{0 \cdot 30103}{3} \log_2 x = 0 \cdot 1 \log_2 x \text{ approximately.}$$

There are no further problems now in the calculation of $c_x = c_0.2^{-x}$, particularly if the slide-rule is also provided with a reciprocal linear scale. Thus, for example, $3{\cdot}2^{-3{\cdot}47} = 3 \times \frac{1}{10{\cdot}35} = 0{\cdot}29$ is calculated in less than a minute.

H. J. OSKAM
A. KOELMAN

Bacteriology Department,
University Medical Hospital,
Utrecht.

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PSYCHOLOGY

Preferences for Different Combinations of Chance and Skill in Gambling

GAMBLING situations range from those where the outcome is, in fact, more or less beyond the player's control to those where the outcome is more or less within his control in so far as it depends on his skill. In any particular gamble, however, the player's decisions are determined by his view of the situation rather than by its objective features. Thus he may consider the outcome as largely or entirely due to skill when the over-riding factor is chance. Many of the millions who fill in football-pool coupons grossly exaggerate the degree to which skill in completing the coupon can influence their chance of success; and even in a national lottery, such as Premium Bonds in Great Britain, the gambler may persuade himself that he is improving his chances of success by contriving to obtain certain ticket numbers and to avoid others.

Imagine now a range of situations such that, at one extreme, the outcome seems to the player to depend almost entirely on his skill, the element of chance being virtually excluded, and, at the other extreme, the outcome seems to him to depend almost wholly on chance, the element of skill being virtually excluded. The question before us is this: The player is offered the opportunity of choosing one combination of chance and skill on which to gamble, is there a combination which would be generally preferred? We may also ask whether there are individual and group differences in preference due, for example, to age, experience, character, or occupation.

We have carried out experiments in which the basic procedure was as follows. The subject was shown a box containing a varied selection of prizes in the form of sweets and chocolates and he was told he would win one if he succeeded in rolling a ball through an aperture. He stood at one end of a table at the other end of which was a variable aperture which could be adjusted to any width up to 2 ft. At stage 1, the experimenter began to widen the aperture and the subject was asked to stop him when he thought he could get the ball through, say, four times in ten attempts. This procedure was repeated with a second variable aperture, and this time the subject stopped the experimenter when the gap was such that he thought he could get the ball through, say, six times in ten attempts. At stage 2 the subject was told that he could only attempt to roll a ball through an aperture if he succeeded in drawing (blindfolded) a red ball from a bag containing ten balls. If he chose the smaller aperture he would have to draw a ball from a bag containing six red balls in the ten. If he chose the larger aperture he would have to draw a ball from a bag containing four red balls in the ten. The product of the two subjective probabilities, that of drawing a red ball and that of rolling it through the gap, was 0·24 in both instances. In this experiment the subject thus chose between two different combinations of probabilities where the product of the subjective probabilities remained constant.

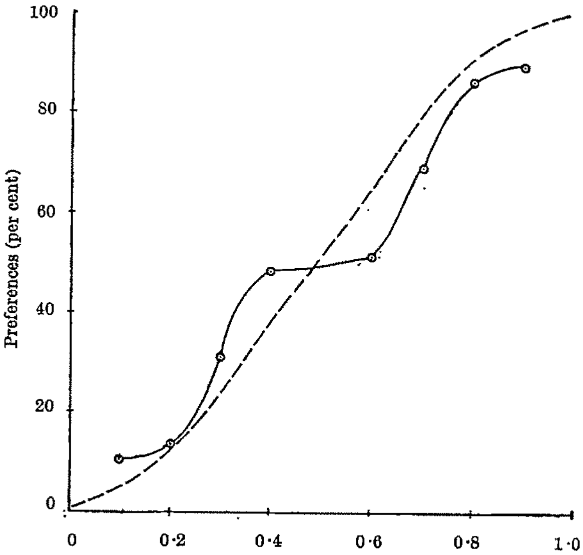

Fig. 1. Preferences plotted against the degree of chance

Four different such choices were presented in random order. In each case the subject had to choose either a larger gap and a smaller proportion of red balls or a smaller gap and a larger proportion of red balls. After the choice in the fourth situation the subject was allowed an attempt to draw a ball which he could aim at the gap and, if successful, win a prize. The four situations and the resulting choices are set out in Table 1. There were 29 male subjects of average age fifteen years.

In Table 1 the value 0·9, for example, under 'skill', means that the subject thought he could roll the ball through a gap nine times out of ten; and the value 0·1, under 'chance', means that there was one red ball in the bag. The preferences are plotted in Fig. 1 against the element of chance in the four situations.

It may be inferred from the figures in Table 1 that whenever a choice has to be made between leaving more to skill or leaving more to chance the subject prefers to rely more on skill, or to leave less to chance, or both. This tendency to rely more on factors within one's control or to rely less on factors outside one's control become more marked as the

Table 1. CHOICES IN SITUATIONS INVOLVING LESS SKILL AND MORE CHANCE OR MORE SKILL AND LESS CHANCE, THE PRODUCT OF THE TWO SUBJECTIVE PROBABILITIES REMAINING CONSTANT (PERCENTAGES)

Alternatives Skill – Chance *or* Skill – Chance (*a*)		(*b*)		Choices (*a*)	(*b*)	Total
Skill	Chance	Skill	Chance			
0·9	0·1	0·1	0·9	10·3	89·7	100·0
0·8	0·2	0·2	0·8	13·7	86·3	100·0
0·7	0·3	0·3	0·7	31·0	69·0	100·0
0·6	0·4	0·4	0·6	48·2	51·8	100·0

Table 2. PREFERENCES FOR A PARTICULAR COMBINATION OF SKILL AND CHANCE OUT OF SIX POSSIBLE COMBINATIONS, *A* TO *F*, WITH THE SAME COMPOUND PROBABILITY (PERCENTAGES)

	Skill	Chance	Preferences		
			Grammar school boys	Training college students	Combined groups
A	0·167	1·000	30·9	36·4	34·2
B	0·250	0·667	20·3	15·3	17·3
C	0·333	0·500	34·5	44·1	40·1
D	0·500	0·333	10·7	1·7	5·4
E	0·667	0·250	—	0·8	0·5
F	1·000	0·167	3·6	1·7	2·5
			Total 100·0	100·0	100·0

outcome becomes increasingly dependent on one or other of these two sets of factors.

We still do not know, however, what would be preferred if the subjects were offered a range of such choices in which the total subjective probability remained unchanged. For example, would subjects prefer the combination 0·8 and 0·2 or 0·4 and 0·4? Accordingly, in a second variation of the experimental procedure, other groups of subjects chose one out of six different skill–chance combinations with the same compound probability. In order to be able to offer a wider choice of equivalent compound probabilities, the gap had now to be adjusted to a given number of successes out of a total of twelve attempts and there were twelve balls in the bag. The resulting decisions are shown in Table 2. The sample consisted of 202 subjects, including 84 grammar school boys aged about fifteen years and 118 training college students, male and female, ranging in age from eighteen to forty years.

From the figures in Table 2, together with the reasons given by the subjects for their choice, certain distinctive preferences are evident. First, the vast majority prefer to rely more on their skill than on chance. Secondly, rather more than a third of the subjects prefer to eliminate one source of uncertainty. In most instances (those who chose *A*) the subjects prefer to rule out the possibility of not drawing a red ball; in other words they are anxious to be certain of an attempt to roll a ball through the gap. Thirdly, there is a considerable proportion for whom *C* is the most popular, that is, the situation when there is an even chance of drawing a red ball. This feature is repeatedly emphasized in the subjects' reports. Among the sub-groups of which the grammar school boys were composed, 50 per cent (14 out of 27) of those specializing in classics preferred *C* as compared with only 20 per cent (7 out of 35) of those specializing in science and mathematics. On the other hand, only a small proportion of subjects chose *D*, although here there is a subjective probability of 0·5 of rolling the ball through the gap. It would seem then that, in this situation, a subjective probability of 0·5 which relates to chance impresses the subject more than a value of 0·5 which relates to his skill.

Whatever preferences are expressed in these gambling situations depend on the way the subjects entertain their uncertainties relating to skill and chance. In previous studies[1] we have attempted to elucidate the conditions under which uncertainties from different sources are combined. In the present report we have identified the combinations which are preferred when the product of the subjective probabilities remains constant and we have described the characteristic features in a gambling situation which determine these preferences.

JOHN COHEN
C. E. M. HANSEL

Department of Psychology,
University of Manchester.
Feb. 12.

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A Priori Probabilities in Gambling

WHEN persons observe randomly generated events of different kinds and are afterwards required to report on the frequency with which each kind of event occurred, they tend to over-estimate the frequency of occurrence of infrequent events and under-estimate that of comparatively frequent ones[1,2].

When persons are offered a choice of bets in a gambling situation they tend to over-value bets involving a low probability of a high gain and under-value bets involving a relatively high probability and low gain. This is true both of behaviour observed in the psychological laboratory[3] and that observed at race meetings[4]. It has been suggested that this is due to an over-estimation of low probabilities and an under-estimation of high ones[3]. This would be in accord with the observations quoted above. But such a simple analysis of the gambling behaviour has been challenged[5] on the grounds that a subjective scale of values for the stakes and prizes which did not correspond to the objective monetary scale (for example, one in which a prize of five pounds was worth more than twenty times a stake of five shillings) could also account for these findings.

I have attempted to examine the question of *a priori* probabilities directly by using a laboratory gambling task and questioning subjects before they begin to play.

In my first experiment subjects had a choice of three bets. One bet had long odds ($P = 0{\cdot}2$), one medium ($P = 0{\cdot}5$), and one short ($P = 0{\cdot}8$). Subjects made repeated choices and played for points. Two pay-off matrices were used. With one matrix, the bet having long odds paid off best (expectancy $+ 1$ point per trial), the middle bet had zero expectancy and the bet with short odds was worst with an expectancy of $- 1$ point per trial. With the other matrix the expectancies were reversed (this was achieved by adjusting the size of the prize available for winning and the penalty extracted for losing). 64 subjects were given one matrix, and a second group of 64 the other. The results showed that the worst bet was chosen more frequently when it had long odds than when it had short odds. Thus this task evoked the same kind of behaviour as that described above.

Only one pay-off matrix was used with my second experiment, the one in which it paid to avoid the bet with long odds. 142 fresh subjects were used. Before they began they completed a questionnaire on which they had to state: (1) the number of times a mathematician would say that each bet would pay off if each was played 100 times (it was stressed that a calculation was expected here); (2) the number of times they would actually expect each bet to pay off. The second statement represents their subjective probabilities.

Eleven subjects failed to make correct calculations of the objective probabilities. The statements of subjective probability made by the remaining

Table 1

Objective probability	Long odds $P = 0{\cdot}2$	$P = 0{\cdot}5$	Short odds $P = 0{\cdot}8$
No. of subjects over-estimating	16	23	62
No. of neutral subjects	30	76	33
No. of subjects under-estimating	85	32	36

subjects have been reduced to three categories: over-estimation, neutrality, and under-estimation. They are shown in Table 1.

This shows clearly that the general tendency is to under-estimate the low probability and over-estimate the high one.

The subjects' subsequent behaviour showed some accordance with their subjective probabilities, but the relationship was not simple. In the first ten choices those who over-estimated the probability of the bet with long odds chose it on average 2·75 times, those who under-estimated 1·32 times, and those who were neutral 0·50 times. There are reasons for believing that the neutral subjects were relatively sophisticated: after the subjective probability statements were given, but before the first choice was made, subjects answered questions about the relative merits of the three bets. 21 of the 30 neutral subjects were able to state correctly which bet would pay off best, whereas only 42 of the 85 under-estimators and 5 of the 16 over-estimators did so.

Finally, although there is this correspondence between subjective probability estimates and subsequent choice of bet, it must be noted that within the group as a whole most choices of the worst bet were made by those who under-estimated the probability of its paying off.

H. C. A. Dale

Medical Research Council
Applied Psychology Research Unit,
15 Chaucer Road, Cambridge.
Feb. 10.

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ANTHROPOLOGY and ARCHÆOLOGY

Blood-group Investigation on Central Kalahari Bushmen

During August–September 1958, an expedition organized by the Kalahari Committee of the University of the Witwatersrand (in which the Anthropology Laboratory of the Department of Human Anatomy, Oxford, participated) carried out anthropological, medical, dental and other investigations on Bushmen in the Central Kalahari. The anthropological interest of this study lies in the following: (*a*) two communities examined, some 70 miles south of Ghanzi, were living a primitive hunting and food-gathering existence and could be compared with a third group of Bushmen living on farms in the Ghanzi district; (*b*) the blood of Bushmen from the Kalahari region has not previously been grouped; hitherto all such data have been obtained from Bushmen of South-West Africa; (*c*) the antigens tested included the recently discovered Diego (the serum was kindly supplied by Dr. Layrisse) and also V and Js (sera kindly supplied by Dr. Eloise Giblett). Tests with anti-Diego sera were particularly apposite since some anthropologists have considered it possible that the Bushmen (and Hottentots), on account of their skin colour and frequent possession of an internal epicanthic fold, incorporate a Mongoloid component of distant or even recent derivation. There also is still uncertainty on the exact affinity of the Bushmen to existing Negroid populations. The V and Js antigens are common in Negro populations and therefore supplement information on Negro affinities afforded by other blood-group systems.

The results are given briefly in Table 1 (for unrelated individuals) and will be considered in greater detail elsewhere, along with other genetic evidence obtained from a study of hæmoglobins, haptoglobins and skin colour.

The results indicate that the Central Kalahari Bushmen, like those from South-West Africa, exhibit in general a Negroid pattern in their blood groups, a conclusion already reached by Zoutendyk *et al.*[1]. This is evidenced in the present results by the high frequency of ccDee, along with ccDE in a low frequency and the moderately high CcDe; it is supported also by the ratio of A_2 to A_1, and especially the occurrence of V and Js. For the latter antigens the evidence so far is that a like frequency occurs among the Bantu. The total absence of the Diego antigen recalls a like finding in several Negro populations[2]. It also provides some evidence against mongoloid admixture, as do the low B and the African Rh pattern. The ABO data for these Kalahari Bushmen agree fairly closely with previous results from South-West Africa[3]. The Bushmen, as a whole, as contrasted to Bantu and Negroids generally, are somewhat distinctive in the combination of a high A and a low B frequency and in the complete absence of Rh-negative individuals. It is not likely that there is much admixture in these Bushmen by local Kalahari Bantu since the B frequency is exceptionally low, the O frequency rather high and cde totally absent.

It is difficult from these and previous results to avoid the conclusion that the Bushmen are essentially Negroid, though they have undoubtedly undergone substantial modification, as suggested by various features of their morphology and by their genetic

Table 1. Blood Group Frequencies (Phenotype Percentages) of Central Kalahari Bushmen

Place	No.	A_x	A_1	A_2	A	B	O	AB	CcDe	ccDee	ccDE	C^w	ccddee	V+	Js+	Diego+
South of Ghanzi	72	0	26·38	8·33	34·71	4·17	61·11	0	27·78	65·28	6·94	0	0	4·17	4·17	0
At Ghanzi	42	2·38	26·18	7·14	33·32	2·38	61·90	0	28·57	71·43	0	0	0	7·14	7·14	0
Total	114	0·88	26·32	7·89	34·21	3·51	61·40	0	28·07	67·54	4·39	0	0	5·26	5·26	0
South-West Africa	446	not tested	not tested	not tested	33·86	8·52	56·05	1·57	17·24	78·88	3·89	not tested	0	not tested	not tested	not tested

constitution as revealed by blood-group studies. Judging by skeletal finds, the Bushmen may well have enjoyed a long period of isolation in the southern tip of the South African continent; such isolation, as well perhaps as the selection resulting from their more recent restriction to the inhospitable parts of South Africa, would seem to be the likely agencies bringing about their differentiation from some older Negroid stock.

We acknowledge gratefully help received from Dr. A. E. Mourant and Dr. B. Kaminer. The work was supported by a grant to one of us (J. S. W.) from the Wenner-Gren Foundation for Anthropological Research.

J. S. Weiner

Department of Anatomy,
Oxford.

A. Zoutendyk

South African Institute for
Medical Research,
Johannesburg.
Jan. 20.

[1] Zoutendyk, A., Kopeć, A. C., and Mourant, A. E., *Amer. J. Phys. Anth.*, 11, 361 (1953).

[2] Layrisse, M., and Arends, T., *Nature*, 179, 478 (1957). Junqueira, P. C., and Wishart, P. J., *ibid.*, 180, 341 (1957).

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An 'Australopithecine' Scoop from Herefordshire

Shortly before Christmas last year, I was demonstrating a series of curious scoop-like cannon-bones recovered from the Makapansgat grey breccia during the past year to a group of visitors to show what looked like digging tools when one of the party, Mr. J. W. F. Hampton, said laughingly: "or apple-corers".

On inquiry, I learned that he had suddenly recollected the object in the accompanying photograph around which four of its primeval relatives from Makapansgat are grouped. It was made about 1890 by his father, F. H. F. Hampton from the cannon-bone of a sheep.

The elder Hampton then lived at Ledbury in Herefordshire but fortunately he brought the apple-corer to South Africa with him in 1926, and to his son it had been a diverting mantelpiece ornament. These sheep cannon-bone scoops were still in general use in the early part of the present century in Herefordshire.

They were made chiefly for elderly folk, who loved crisp apples but had lost their teeth, to core their fruit, scoop out the flesh and convey it to their mouths in the form of a pulp. The custom died with the advent of false dentures, a decease doubtless expedited by its cheap metallic replacements in modern chain stores.

The scoop on its left shows the ancestral form from Makapansgat; the cannon-bone on its right with the depressed fracture running along its posterior aspect illustrates the original mode of manufacture, which will be discussed in more detail elsewhere. All that need be said here is that, as no stone tools whatever have been found during the development of seven tons or more of this grey breccia, the fracturing was done by the calculated and repeated impact of bone upon bone.

The two specimens in the top row are included to show that these scoops were made in different sizes and were used right down to the base, even the articular surfaces becoming worn by the severe attrition to which they were subjected.

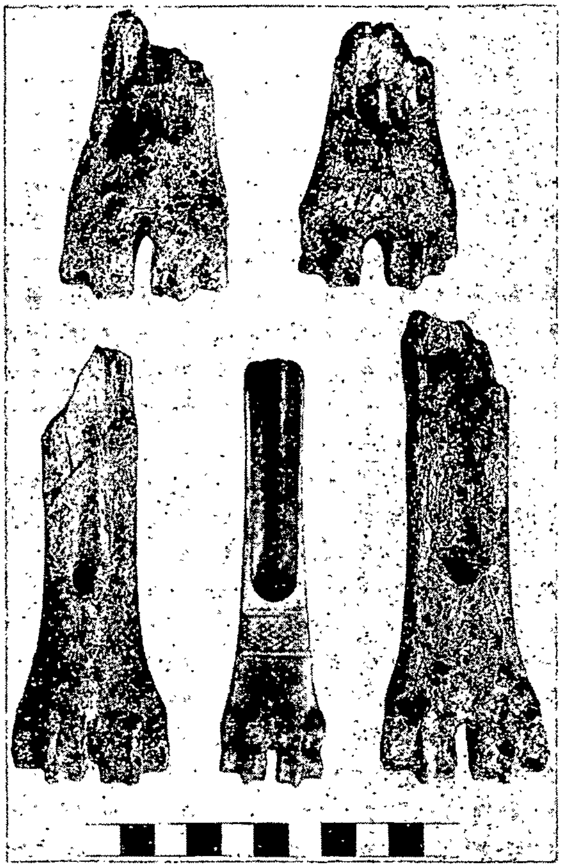

Fig. 1. Four antelope cannon-bone scoops from the australopithecine grey breccia at Makapansgat Limeworks grouped around the central Late Victorian sheep cannon-bone apple-corer made by Mr. F. H. F. Hampton of Rustenburg in the Transvaal about 1890 and resident in Ledbury, Herefordshire, until going to South Africa in 1926. The scoop on its left shows the directness of the comparison to be drawn between the ancestral australopithecine scoop and its recent British counterpart. The scoop on its right illustrates the australopithecine mode of manufacture by percussional linear fracture of the posterior wall of the bone. The two specimens in the upper row are larger forms of the fossil scoop worn down almost to their base by use. (Centimetre scale)

Some of them are so smooth that they look as though they had been oiled and polished; but this unexpected evidence from Herefordshire makes the conclusion inevitable that their state is probably due to their service as scoopers of flesh, fat and other fluid pulps and as conveyors of them to the mouths of toothless infant and aged australopithecines.

I am indebted to the generosity of the Hampton family for permitting me to photograph this fortunately preserved relic, and for their unexpected contribution to the resolution of a problem that has mystified me for the past year. The conservatism of mankind as well as the inventive genius of *Australopithecus prometheus* has been illustrated here by a utensil that seems to have had the lengthiest run of any contrived by human intelligence.

Raymond A. Dart

Medical School,
University of the Witwatersrand,
Johannesburg.
Jan. 25.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, March 23

Institute of Actuaries (in Staple Inn Hall, High Holborn, London, W.C.1), at 5 p.m.—Mr. J. A. Westcott and Mr. E. M. Smith: "The Valuation of Annuity Business".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. C. T. Smith: "Some Aspects of Agriculture and Settlement in Peru".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. M. L. Gayford: "High-Quality Microphones"; Dr. F. A. Benson and Mr. P. M. Chalmers: "Effects of Argon Content on the Characteristics of Neon-Argon Glow-Discharge Reference Tubes".

Tuesday, March 24

Physical Society, Acoustics Group (in the Physics Department, Imperial College, London, S.W.7), at 2.15 p.m.—Symposium on "Recent Studies of Noise Problems".

Society of Chemical Industry, Fine Chemical Group (in the Chemistry Department, Birkbeck College, Malet Street, London, W.C.1), at 4 p.m.–8 p.m.—Exhibition on New Laboratory Apparatus and Techniques.

Society of Instrument Technology (at Manson House, Portland Place, London, W.1), at 6 p.m.—Dr. R. Conrad: "New Directions in Engineering Psychology".

Tuesday, March 24—Thursday, March 26

Institution of Naval Architects (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 10.15 a.m. daily—Spring Meeting.

Wednesday, March 25

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 3 p.m.—Symposium on "Radio Telemetry".

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. D. Hicks: "Investigational Work carried out by the National Coal Board's Scientific Control Organization".*

University College, Department of Pharmacology (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Valy Menkin (Temple University, Philadelphia): "The Role of Inflammation in Carcinogenesis".*

Institution of Mechanical Engineers, Lubrication Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Problems of Lubrication at High Temperatures".

Society of Chemical Industry, Food Group (joint meeting with the Oils and Fats Group, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Mr. J. G. Collingwood: "Developments in the Oil Milling and Animal Foodstuffs Industry".

Oil and Colour Chemists' Association, London Section (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Dr. T. P. Hoar: "Some Recent Advances in Corrosion and Protection Fundamentals".

British Psychological Society, Medical Section (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 8.30 p.m.—Mr. Michael Reed: "Communication and the Deaf".

Royal Society of Medicine (at 1 Wimpole Street, London, W.1), at 8.30 p.m.—Sir John Cockcroft, O.M., F.R.S.: "The Peaceful Uses of Atomic Energy" (Lloyd Roberts Lecture).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Mathematical Physicists (with a first- or second-class honours degree in mathematics or physics), to join a section concerned with the assessment of criticality hazards in the handling and processing of fissile materials and to carry out theoretical research into the factors governing criticality and the effects of supercriticality—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2974/J.14 (March 30).

Associate Professors in Ballistics (Department of Mathematics and Physics); Applied Chemistry (Department of Chemistry and Metallurgy); Mechanics (Department of Civil and Mechanical Engineering); and Radar and Telecommunications (Department of Electrical and Instrument Technology) at the Royal Military College of Science, Shrivenham, Berks—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S.4949/59/9 (March 31).

Lecturers or Senior Lecturers (according to age, qualifications and experience) at the Royal Military College of Science, Shrivenham, Berks, to teach at University level in Mathematics (two posts); Physics (one post); Civil Engineering (two posts); Surveying (one post—Senior Lecturer); Mechanical Engineering (two posts); Radar and Telecommunications or Engineering Physics or Electrical Engineering (five posts)—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S.4947/59/8 (March 31).

Assistant Lecturer in Biochemistry in the Rheumatism Research Centre—The Registrar, The University, Manchester 13 (April 4).

Lecturer in Radiochemistry in the Department of Chemistry of the Faculty of Science—The Registrar, The University, Manchester 13 (April 4).

Lecturer in the Department of Physics—The Registrar, University College of Wales, Aberystwyth (April 4).

Senior Lecturer (with research experience, and preferably industrial experience) in Ceramic Materials—The Secretary-Treasurer, Royal College of Science and Technology, Glasgow (April 4).

Assistant Lecturer (Grade III) or Demonstrator in Chemical Physiology—The Registrar and Secretary, The University, Bristol (April 8).

Research Biochemist (honours graduate, with postgraduate research experience in the analytical and metabolic aspects of biochemistry, especially in the field of nitrogen metabolism) in the Fodder Conservation Section, Commonwealth Scientific and Industrial Research Organization, Australia—Mr. E. J. Drake, Chief Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 400/75 (April 11).

Assistant Lecturer, Grade B (with good academic qualifications), in Zoology—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 13).

Senior Lecturer/Lecturer in Physical Chemistry at the University of New South Wales, Australia—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (Australia, April 14).

Lecturers in Experimental and Theoretical Physics—The Secretary of University Court, The University, Glasgow (April 15).

Professor of Applied Physics—The Registrar, University Office, 46 North Bailey, Durham (April 16).

Lecturer in the Department of Metallurgy, to teach and carry out research in Physical Metallurgy—The Registrar, The University, Liverpool (April 18).

Lecturers (2) (qualified in either pure or applied mathematics) in Mathematics—The Secretary of University Court, The University, Glasgow (April 18).

Post-doctoral Research Fellow in the Department of Fuel Technology and Chemical Engineering, to direct and carry out research on the laws of smoke formation and elimination with all types of fuel—The Registrar, The University, Sheffield (April 18).

Research Fellow in Mathematics, an Assistant in Mathematics, and an Assistant in Statistics—The Secretary of University Court, The University, Glasgow (April 18).

Lecturer (graduate, with postgraduate training in animal nutrition) in Animal Husbandry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 20).

Lecturer in Geology—The Secretary of University Court, The University, Glasgow (April 20).

Senior Lecturer or Lecturer in Zoology at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 23).

Research Officer (Physicist) (with a first- or second-class honours degree in physics, or equivalent qualifications, postgraduate experience in radiation counter techniques, and thoroughly conversant with the physics and construction of ionization chambers, proportional counters, scintillation counters, etc.) in the Technical Physics Section, Australian Atomic Energy Commission, to conduct research into radiation detection techniques and also to develop specialized nuclear particle detectors—A.A.E.C. Liaison Officer, Australia House, Strand, London, W.C.2, quoting "Position R.73" (April 24).

Senior Research Officer (with a degree in medicine and research experience in some branch of medicine or biology); and a Research Officer (with a degree in medicine or science and experience in either biophysics, biochemistry or tissue culture work) in the Section of Biology and Medicine, Australian Atomic Energy Commission, for duties which will include work on acute radiation effects and the cellular effects of radiation—A.A.E.C., Liaison Officer, Australia House, Strand, London, W.C.2 (April 24).

Hives Chair of Thermodynamics—The Registrar, The University, Nottingham (April 30).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Chemotherapy, Engineering, Metallurgy, Pharmacology or Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

National Coal Board Postdoctoral Fellow in Physical Chemistry, for research work in connexion with the study of solids by a number of techniques such as mass spectroscopy—The Deputy Registrar, The University, Edgbaston, Birmingham 15 (April 30).

Professor of Applied Mathematics at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Queensland, Brisbane, Australia (April 30).

Turner and Newall Research Fellow in Engineering, Inorganic Chemistry or Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Assistant Lecturer in Chemistry in the Department of Physiology—The Secretary, Royal Veterinary College (University of London), Royal College Street, London, N.W.1.

Entomologist (B.Sc. biology with specialization in entomology) in the Ministry of Health, Government of the Northern Region of Nigeria, to work on control of *Simulium damnosum*, the vector fly of onchocerciasis—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/408/027.

Head (graduate with extensive experience of British agricultural crops and experimentation) of the Trials Branch—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Head of the Physics Department—The Headmaster, Campbell College, Belfast.

Master to teach Physics to A level and Mathematics to O level—The Headmaster, King's School, Rochester.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

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This is Apartheid. By Leslie Rubin. Pp. 16. (London: Victor Gollancz, Ltd., 1959.) 1*s.* [191

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International Wool Secretariat: Department of Education. Sheep Husbandry at Home and Abroad. (Reprinted from *Wool Knowledge.*) Pp. 82. (London: International Wool Secretariat, 1958.) 3*s.* 6*d.* [191

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Department of Scientific and Industrial Research. Notes on D.S.I.R. Grants for Graduate Students and Research Workers. Pp. 28. (London: H.M. Stationery Office, 1959.) 1*s.* 9*d.* net. [191

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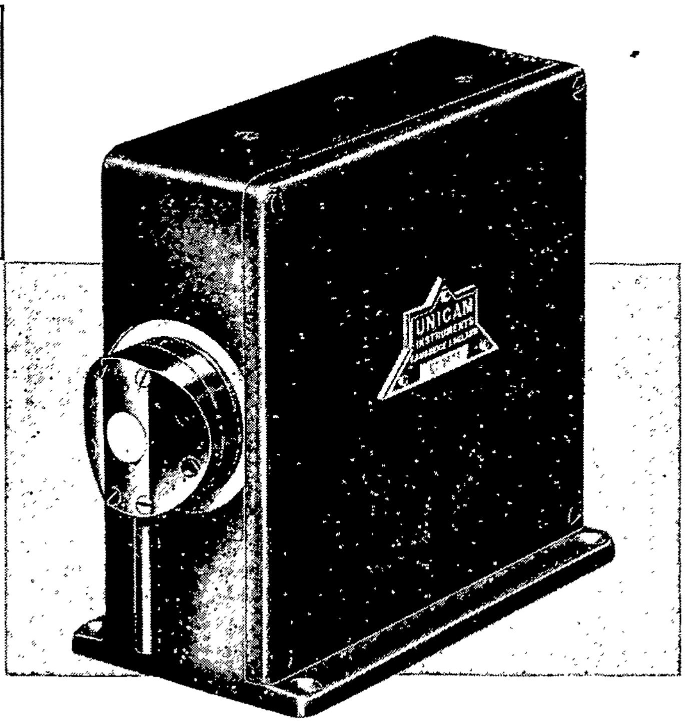

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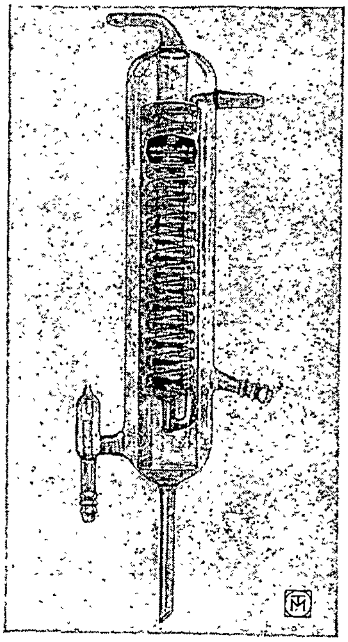

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SCIENTIFIC AND TECHNOLOGICAL RESEARCH IN BRITAIN

IN its tenth annual report, the Advisory Council on Scientific Policy published estimates of the national expenditure in Britain on research and development in 1955–56, and of the man-power engaged in that effort, supplementing those given in the report "Scientific and Engineering Man-power in Great Britain" which was issued in the previous autumn. These estimates were based, so far as private industry was concerned, on the preliminary results of an inquiry conducted by Mr. E. Rudd, of the Department of Scientific and Industrial Research, to discover the cost of scientific research and technical development carried out by private manufacturing industry in Great Britain in 1955. The final results of this inquiry have now been presented in a White Paper* issued by the Department and setting forth the considered views of the Economics Committee of the Council for Scientific and Industrial Research. The chairman of that Committee, Prof. E. A. C. Robinson, contributes a foreword.

Prof. Robinson stresses three points. The figures are believed to give as reliable an indication of the scale and distribution of research expenditure in the main sectors of manufacturing industry in Britain as is possible to obtain in present circumstances; but the Committee is aware that estimates of research and development expenditure for individual industries more narrowly defined are subject to margins of error which increase with the extent of the subdivision. Secondly, considerable caution is necessary in reaching conclusions as to the adequacy or inadequacy of research in any particular industry. Frequently the research expenditure of an operating industry considerably under-estimates the volume of relevant research. Thirdly, research and development do not represent the only means by which science can be applied to industry, nor are the limits either of research or development easily and clearly definable. The application of science to industry occurs in departments concerned with design and the improvement of production, as well as in the research and development departments.

The man-power inquiry, carried out by the Social Survey on behalf both of the Department of Scientific and Industrial Research and the Ministry of Labour and National Service, sought information from all manufacturing establishments employing 500 workers or more, and from a sample of those employing between 100 and 499. The second part of the inquiry, which sought to relate man-power with expenditure, collected information from some 238 firms, and more detailed information was obtained from another 94 firms. All these firms volunteered the information, but although the industrial coverage was incomplete and the firms were not a statistical sample, it is believed that the average cost of £1,300 per person employed on research and development in private industry is reasonably accurate. When used, however, to estimate expenditure on research and development in all manufacturing industry, except aircraft, this figure probably leads to under-estimation rather than to over-estimation.

Under research and development, those replying to the questionnaires were asked to include basic and fundamental scientific research and also applied research, technical development and technical service work, including technical design work, done in connexion with different raw materials, or in introducing new working methods. Manufacturers were asked to include prototype production, but to exclude routine analyses, inspection, production, testing and quality control; detailed design of manufacturing units based on information supplied by research; tooling-up and similar preparation for full-scale production, after the development of new plant; and normal production for sale, market research and the selling of an established product.

The survey indicated that in 1955, 109,500 full-time workers were employed in Great Britain by private manufacturing industry on scientific research and technical development at a total cost of £183 million. Since manufacturing industry contributed £6,535 million to the gross national product, expenditure on research and development represented 2·8 per cent of this contribution; but nearly 44 per cent of this research development expenditure is accounted for by the aircraft industry, and this £80 million came largely from Government defence contracts. According to estimates of the Advisory Council on Scientific Policy, defence contracts contributed £118·4 million to research and development in private industry, and on that basis industry's own expenditure on research and development was less than 1 per cent of its contribution to the gross national product. Metal manufacturing and the engineering industries, including vehicles and aircraft, accounted for 77 per cent of the total expenditure on research and development, and the chemical industry, including mineral oil refining, for another 13 per cent.

According to the man-power survey, some 130,000 people are engaged on research and development in private manufacturing industry in Britain, but of these 37,662 are part-time; 35,215 full-time and 14,767 part-time are engaged in the metal manufacturing and engineering industries and 14,810 full-time and 7,138 part-time in the chemical industries. Of the total, 48,829 qualified engineers and scientists are employed in all manufacturing industries; of these, 14,855 scientists and 14,341 engineers are employed in research and development. engineers predominating in the metal-using industries and scientists in the chemical industries, which employ 5,862, or more than two-fifths, of all the scientists engaged on research and development in manufacturing industry. The textile industries employed 765 scientists and 241 engineers on research and development, largely in the man-made fibre industries. The ratio of supporting staff averaged 1 : 3 for all industry and ranged from 1 : 7·5 for aircraft and 1 : 6 for other vehicles and components to 1 : 1·5 for the chemical industries and metal manufacture and 1 : 1 for food, drink and tobacco.

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* Department of Scientific and Industrial Research. Estimates of Resources devoted to Scientific and Engineering Research and Development in British Manufacturing Industry, 1955. Pp. 50. (London: H.M. Stationery Office, 1958.) 3s. net.

More than half the research and development workers covered by the survey were employed in 683 establishments employing 1,000 or more workers, and together totalling about 37,000 workers, and this average of 55 research and development workers per establishment compared with an average of five in the smallest establishments included in the survey. Moreover, 80 per cent of research and development workers were employed in the 309 firms with research and development staffs of more than 50, and the 2,031 establishments employing 10 or fewer persons in research and development only employed 8 per cent of the total. Afterwards it was estimated that 58 companies or groups account for about £60 million of the total expenditure on research and development in private industry in Britain.

Research and development expenditure as a percentage of the net output averaged 3·5 for all industries, or 2·0 excluding aircraft, and varied from 35·1 for aircraft, 6·8 for electrical engineering and 4·8 for chemical industries, to 0·2 for wood and cork and 0·1 for clothing. Per person it averaged £30 for all industry (or £17 excluding aircraft) and varied from £354 for aircraft, £70 for chemical industries, £56 for electrical engineering, £21 for precision instruments, jewellery, etc., to £0·3 for clothing. In addition to the £183·2 million spent by industry in its own research and development establishments, another £8·9 million is contributed from the research associations and from research stations of the Department of Scientific and Industrial Research, and in the shipbuilding and marine engineering industry this contribution amounts to 81 per cent of the expenditure on research and development. It exceeds 50 per cent in five other industries: boots and shoes (67); linen, jute, hosiery, knitwear and lace (61); wool and worsted (58); cotton (56); and the manufacture of wood and cork (55). In leather, leather goods and fur, it is 38 per cent, and in ceramics 32 per cent.

These figures obviously bear closely on the position of the research associations and indeed of the research stations of the Department of Scientific and Industrial Research, and will no doubt be carefully weighed by the Council of Scientific and Industrial Research in reaching its decisions as to the future of any particular research association or research station. Moreover, while it is desirable, for example, that a research association should receive the maximum support from the industry it serves, the best means of encouraging such support may well vary from industry to industry and depend considerably on the structure of the industry and the size of its units. The predominance of smaller firms may well make this a matter of considerable difficulty in view of the concentration of existing research activities in the larger firms, and added to this there is a widespread illusion among the smaller firms that the larger firms derive proportionately the greatest benefit from co-operative research.

This is possibly true in so far as a smaller firm employs no one capable of assessing the significance of scientific advance for its own activities, and in this connexion the expansion of Britain's effort in research and development is partly an educational problem depending on the supply of sufficient numbers not merely of well-trained scientists and technologists but also of those capable of appreciating the nature and value of scientific work. It is related to education for management in the broadest sense—to ensuring that those who enter industry are at least able to understand the dependence of industry upon technological advance and to make effective use both of the services of scientists and technologists and the new knowledge which is being placed at their disposal. No conclusions are drawn from the estimates in this White Paper, nor are any recommendations included; but the Council for Scientific and Industrial Research and the Advisory Council for Scientific Policy must clearly proceed with great care at this juncture in determining their policy in regard to the research associations and to the research stations. A false step could do much to jeopardize expansion and an apparent immediate economy might prove to involve much wasted effort and greater expenditure in the long run.

The survey was concerned solely with private industry, and only to this extent touches on the research and development effort of the central Government. Even the adequacy of the industrial effort, however, cannot be assessed realistically without reference to the Government effort and to that of the universities and the independent research institutions. A broadsheet issued by Political and Economic Planning shortly after the White Paper was published (No. 430; January 19, 1959) provides a somewhat wider perspective, although it is limited to a survey of scientific and engineering man-power. This is a revised version of a paper written in 1957 by Mr. R. Fort for the Scientific and Technical Committee set up by the North Atlantic Treaty Organization's Conference of Parliamentarians. Although, like Mr. Rudd's survey, it draws largely on "Scientific and Engineering Man-power in Great Britain", it is supplemented by information obtained from the Office of the Lord President of the Council and, besides summarizing the present position of scientific and engineering man-power in the United Kingdom, it reviews briefly Government policy for increasing such man-power, possible improvements in the use of scientific and engineering man-power, trends in education and the content of education in science and engineering.

The survey of the present man-power situation adds little to that given in the last report of the Advisory Council on Scientific Policy. It points out, however, that if we are to aim at about 20,000 young people a year graduating in pure and applied science by 1970, attention to the number of supporting technicians is imperative. The total number of technicians qualifying in 1957 was about 21,000, and this figure may be expected to increase as firms release more students to attend part-time day classes. It is, however, a long way below the figure of up to five or six for every fully qualified scientist or engineer; Mr. Fort's comment that, as more young people recognize the value of a formal qualification, the output from existing courses may have to be doubled to make sure that the numbers of technicians keep pace with the increasing numbers of qualified scientists and engineers, is more likely to be an under-estimate than an over-estimate.

No fresh suggestions for improvements in using trained scientists and engineers are made in the broadsheet, though a little stress is laid on the possibility of using more women scientists in industry. Mr. Fort points out, however, that there is scope for more men and women with scientific and technological training in responsible administrative and commercial posts, where their better understanding of the fundamental problems of the industry in which they work should contribute to greater efficiency and to higher productivity. This in itself accentuates the need for a higher output of scientists and engineers, and for doing everything possible to ensure that they are not employed on work which could be done just as well by technicians or other less highly qualified people.

As regards trends in education, Mr. Fort notes the high wastage among those leaving secondary technical and modern schools at fifteen or sixteen to enter industry and to attend evening courses leading to technician and craft certificates. Only about one in ten of those who start Ordinary National Certificate courses continue to success in the final examination. The wastage in part-time day courses is less, and the trend is towards increasing release for day courses; but it is estimated that 30,000 additional teachers will be required to provide for the increase in part-time day-release students which will result from the increased post-war birth-rate and the introduction of compulsory day-release. Here, again, Mr. Fort points out that the shortage of science teachers is the most serious aspect of the situation, and in discussing the content of education and the relation between school and university education he notes that perhaps one third of the boys and girls in schools are undecided in their preference of science or the arts.

To increase the supply of scientific man-power, therefore, school curricula should be drawn up so as to encourage pupils to decide to take science, while avoiding over-specialization; and university entrance standards should make it as easy as possible for the schools to strike the balance between giving a broadly based education and encouraging the undecided to take science. More specifically, Mr. Fort notes that many pupils at school seem to be discouraged from taking science by their failure to master enough mathematics, and this failure suggests that the methods of teaching may be faulty. Indeed, the most positive contribution of the broadsheet is perhaps its suggestion that at the heart of the whole problem of expanding scientific and technological man-power is the provision of more science teachers in schools; and that attracting more pupils to take science first in the schools and then in the universities, and improving the teaching of mathematics are probably the two most promising steps for providing more such teachers. The first of these comments strongly underlies Dr. Kenneth Hutton's forthright speech at the North of England Education Conference at Scarborough and the Government's dilatoriness in dealing with the three critical factors on which the improvement of science teaching depends.

These two surveys thus demonstrate how interlocked is the whole question of scientific and technological man-power in Britain and our effort in research and development with education generally. They indicate once again the danger of determining policy in any particular sector without reference to repercussions elsewhere. They do not suggest that the present target for scientific and technological man-power is inadequate, but they throw little light on how the redistribution of present or future effort should be effected. The adequacy or inadequacy of research and development in a particular industry can be assessed only by reference to the organization of that industry and its essential characteristics and to the magnitude of the country's effort in fundamental research and the effectiveness of communications. The survey of industry's own effort needs to be supplemented by a corresponding survey of research and development in Government establishments, and by yet another survey of fundamental and applied research in the universities, colleges of technology and in independent research institutions. Moreover, even when the relative magnitude of the effort in terms both of money and of man-power in these different sectors is known, we need to know more about the efficiency with which it is conducted and the adequacy with which the scientist and technologist is supported with equipment as well as with technicians and craftsmen.

It is now more generally recognized that research in the universities needs much more generous support in these respects, but the distribution of fundamental research as between the universities, the independent research institutions, the research associations and the research stations of the Department of Scientific and Industrial Research deserves much more attention. It cannot wisely be decided without clear conceptions as to the functions of these various institutions and the relation of such research to their other functions. Any changes in the work of the Department of Scientific and Industrial Research should follow and not precede such conceptions. It does not, in fact, appear that the Council is as yet prepared to say how far the Department should engage in pure research even in its own research stations, let alone how far the research associations should conduct such research; yet the answer given to the latter question determines considerably the extent to which industries now served by the grant-aided research associations can be fairly expected to bear the full financial responsibility for the research associations.

Again, even if the Department's responsibilities for research of direct application to industry are determined largely by the extent to which further research is likely to be stimulated in industry, the extent to which the Department's own stations should engage in such research will not easily be decided without considering the further problem of how to allocate available resources effectively in order to meet the demands which team-work and highly expensive equipment now make. The Council, in its first annual report, indicated that these questions were already being considered. Its second report will certainly be awaited with considerable interest and some anxiety; but in the meantime these surveys have done something to clarify the picture, and to indicate the points at which further information on the national effort is needed—and some at which action is urgently required—if only to check existing waste and to increase the effectiveness with which present limited resources in trained man-power or expensive equipment are used. Even while new policies are being devised, much could be done to make far more effective use of present expenditure and resources, given sufficient imagination, co-operation and drive.

THE FATHER OF CHEMISTRY

Robert Boyle and Seventeenth-Century Chemistry
By Prof. Marie Boas. Pp. viii+240. (Cambridge: At the University Press, 1958.) 30*s*. net.

DR. MARIE BOAS, assistant professor of the history of science in the University of California, gives an account of the achievements of seventeenth-century chemistry with Robert Boyle as the central figure. The foundation of his development as a scientist is doubtless his early interest in collecting medical recipes and preparing medicaments. He soon became an ardent experimentalist, using the "Book of Nature" as his teacher. He came to regard chemistry as "highly conducive to the true knowledge of Nature", and to be not only a necessary part but also a respectable and useful part of natural philosophy, able to "contribute to its advance as a whole".

The chemical and physical theories of matter current in Boyle's time did not satisfy him, and he developed a mechanical, corpuscular theory, based on experiment, by which he strove to banish all occult notions from natural philosophy. In "The Sceptical Chymist" he demolished the established theory of elements in its various forms, and ended by being doubtful of the existence of any elements. Dr. Boas points out the great difference between the concept of elements then and now, and stresses its importance for a proper understanding of seventeenth-century chemical theory and Boyle's objections to it. His rejection of the old view of a chemical element paved the way for the concept of simple substances, which led ultimately to the new definition of element. His firm belief in corpuscular philosophy apparently provides the explanation of his belief in transmutation, since he considered the change from one metal to another to involve merely a change in corpuscular structure.

The increase in the number of substances resulting from experimental work inevitably raised the problem of chemical composition. Throughout this period the attempt was made to improve chemical nomenclature, basing it on chemical entities instead of imaginary elements or principles. Chemical reactions presented great difficulty, and only gradually came to be regarded as a combination or an interchange of chemical entities. The method of analysis by fire frequently gave very good results, but difficulties in interpretation arose from the confusion caused by variations in experimental technique, and inaccurate nomenclature. Chemical identification tests were greatly extended in scope by Boyle, who evolved precipitation tests, colour reactions, flame tests, and indicators for alkalis.

At an early date Boyle interested himself in chemical classification. His successful classification of acids, alkalis, and neutral substances killed the acid-alkali theory of matter. He recognized that acids had two parts: one that caused all acids to give a colour change with an indicator; the other that made one acid different from another. He was not so successful in his attempts at nomenclature for salts. Boyle's experiments on air are discussed. He could not "believe that the elastic particles of the air are really chemical entities", and he regarded fire, rather than air, as the chief agent responsible for calcination, and the increase in weight of metals.

Boyle's scientific method and experimental technique are discussed in the final chapter. His writings are prolix and frequently tedious; his method of preserving the records of his work prior to publication was haphazard, if not careless; but in contrast to this his experimental work was carefully conceived, detailed, and properly noted at the time. He was a shrewd observer, and no stranger to the use of quantitative methods, even if he was not as accurate with them as he could have been, and at times failed to interpret the results correctly.

The bibliography adequately covers the subject. The index, too, is adequate, but curiously omits all mention of any of the works of Boyle discussed in the text. For references to Boyle's life the octavo edition of 1744 has been used, and for his works the folio edition of the same year. From the point of view of accessibility the quarto edition of 1772 would perhaps have been a better choice for both purposes. Some of the references to the archives of the Royal Society are confusing because the system of nomenclature used by that body has not been adopted. The following corrections, among others, may be noted: p. 9, Boyle returned to England in mid-1644, not in 1645; p. 11, *Add. MSS* 4316 should be 4314; p. 24, Gerard Boate died in 1650, not 1653; and "Ireland's Naturall History" was published under his name as sole author; p. 30, Boyle was in Ireland by the last week of June 1652; p. 211, the reference should read "Royal Society. Correspondence. Early Letters. Guardbook B.1. 100", and the date of the letter is "9 Dec" not "2 Dec". These, however, are minor errors, and in no way detract from the brilliance of this important book, in which Dr. Boas, with a skilful marshalling of widely distributed facts from Boyle's works and papers, conducts the reader in virtuoso manner through the labyrinth of seventeenth-century chemical thought and practice.

R. E. W. MADDISON

PLASTICS FOR THE PRACTICAL MAN

Polyurethanes

By Bernard A. Dombrow. (Reinhold Plastics Applications Series.) Pp. ix+176. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 4.50 dollars.

Polyamide Resins

By Don E. Floyd. (Reinhold Plastics Applications Series.) Pp. viii+230. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 4.50 dollars.

Plastic Sheet Forming

By Robert L. Butzko. (Reinhold Plastics Applications Series.) Pp. ix+181. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 4.50 dollars.

Cellulosics

By Walter D. Paist. (Reinhold Plastics Applications Series.) Pp. xi+270. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 5.75 dollars.

Fluorocarbons

By Merritt Allen Rudner. (Reinhold Plastics Applications Series.) Pp. x+238. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 5.75 dollars.

"THE Modern Plastics Encyclopedia" for 1958 lists 102 books on plastics and high polymers published since 1950. To this literature, a new series of monographs has been added (Reinhold Plastics Application Series) of which six have been issued while ten more are in preparation. Their appearance coincides with a recent decision of the Plastics Institute to make its set of eleven titles in the Plastics Monograph series available to the public through an arrangement with Messrs. Iliffe.

Any protest at this profusion of books on plastics must be tempered by the awareness of much disagreement existing between the experts as to the very nature of plastics as displayed at the recent Polymer Tribunal. In any event, any new book may be welcomed if it largely comprises new material or a novel presentation, and it is in this spirit that the present series may be reviewed.

In "Polyurethanes", a brief account of their chemistry is followed by chapters on foams, rubbers and surface-coating and adhesive applications. The book makes clear which are the commercially important raw materials and the manner in which the systems function in diverse applications. It contains a useful account of polyurethanes derived from castor oil, and hindered and reversible systems and, despite the absence of serial references, should have a reasonably wide appeal.

"Polyamide Resins" is written with a chemical slant, and serial references are given to published work. The book contains little that is new about fibre-forming polyamides and may be valued principally for the information it gives on the novel 'Versamid' dimeric fatty acid/polyalkylene amine polyamides and their blends with epoxy resins, with which the author is specially familiar by virtue of his association with General Mills Inc.

The reader of "Plastic Sheet Forming" will be impressed with the scope of this versatile technique by the long list of applications assembled. Nineteen variations of the process illustrated by easy-to-follow diagrams and an account of commercially available equipment, including cost estimates, makes it possible to recommend this as a very useful practical guide to those contemplating the use of the sheet-forming process.

In contrast with the three books listed above, the author of "Cellulosics" has had to deal with a subject in which there is a very considerable literature. The presentation ranges from fabrication techniques for spectacle frames to the dyeing of woven fabrics. In attempting to cover all outlets for cellulose and its derivatives, the book is of proportionately reduced value to the student of plastics. Neither references nor a separate bibliography are given. Table 3.5 requires correction.

The title of "Fluorocarbons" is somewhat misleading, for the book contains no mention of materials other than polymers of tetrafluorethylene and monochloro trifluorethylene. Even on these, there is little information not normally available from sales and technical bulletins. The term molecular weight is often used in the wrong sense, and a chapter on the chemistry of fluorocarbons (written in collaboration with Claude Bunnell) is marred by misprints.

In an ostensibly uniform series of monographs, a bad impression created by any one book tends to prejudice the reader against the remainder of the series. Such a temptation should be resisted and, as this review shows, each monograph should be appraised on its own merits. One overall criticism, which is often made in regard to American publications, is that the price per book will be considered high in Britain in relation to the value. S. H. PINNER

MAMMALIAN HAIR

The Biology of Hair Growth

Edited by William Montagna and Richard A. Ellis. Pp. xvii+520. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 15 dollars.

THIS book, equivalent to proceedings of the Conference on Hair Growth held in London in 1957, is a revelation of progress and promise. Those working on hair will need no encouragement to keep this book always at hand. It reports a modern breakthrough, by new techniques and experiment, largely in young branches of old sciences, often concerned with very minute structure and tiny quantities. Hair is very favourable material for relating biochemistry to morphology. Though much remains to be discovered, Montagna may reasonably claim, after surveying recent advances which emphasize how precise is the control of the intense activity of the follicle, that "the understanding of the prime forces that guide and control hair growth cannot be far off".

As an organ, the hair follicle corresponds in convenience with Protozoa among animal types, and examples follow of phenomena and principles of which bio-scientists in other fields may care to take note. Cell division is an all-or-none reaction, and even the death of the animal does not arrest it (Bullough, on mitosis). Some treatments inhibit initiation of growth, but have no effect on follicles already growing (Mohn, and Montagna's summary). An intricate balance of many hormones is required for the normal occurrence of the periodic waves of spontaneous replacement in the rat (Mohn). The response of follicles to treatments depends on the phase of the growth-cycle in rodents, and in man (Van Scott). The presence of growth-waves in the rat, and their absence from the guinea pig, are probably related to vascularization (Durward and Rudall). In fibrogenesis the same end-result is evidently reached by different routes (Mercer). Reduction of the size of the follicle in catagen is retrograde morphogenetic transformation, not degeneration in the usual sense (Montagna and Van Scott). The idea that the cell components may first dissociate and then reunite is a contribution to thought on the mode of working of the gene (Rothman).

Practical application is being sought chiefly in the extremely odd coats of fleece-bearing sheep and man, which both pose fascinating problems in evolution. As to wool, more reciprocal trade is desirable between mouseries and both farms and mills. With reference to human cancer, all that will be said here is that work on the inheritance of coat colour in rodents half a century ago was research now related to human cancer (Fitzpatrick *et al.*, p. 279). A still more widespread killing disability in the human race is maleness. Apparently there is a spectrum in which tendencies to highly developed secondary sex characters merge with tendencies to sex-selective pathological states, rapid aging, and short duration of life (Hamilton, p. 431). Any new fact about hair may save male life and wits.

In gratitude to the late Prof. Walter Garstang this opportunity is taken to report that he coined the terms for growth-phases, anagen, catagen, telogen, and the names of the fibre types monotrich, awl, and auchene, in one short discussion. For the fourth fibre type he then proposed ptychotrich, but a few days later substituted zigzag. F. W. DRY

THEORETICAL PRINCIPLES OF ORGANIC CHEMISTRY

Theoretical Principles of Organic Chemistry

Vol 2. By Prof. Walter Hückel. Translated from the corrected 7th German edition by Prof. F. H. Rathmann. Pp. xi+1046. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1958.) 95*s*.

THIS completes the translation of Prof. Walter Hückel's text-book, the first volume of which was reviewed some three years ago (*Nature*, 176, 991; 1955). It was concerned in part with valency theory and stereochemistry, dealt with under the heading of chemical statics; and in part with structural rearrangement and the chemistry of unsaturated compounds, dealt with under the heading of chemical dynamics.

The present volume deals with constitution as it determines physical properties and reaction velocities. Under the former heading are considered, *inter alia*, thermodynamic, electrical, and optical properties; relations between cohesion and constitution; properties of organic colloids and crystals; and the nature of the chemical bond. Under the latter are considered general theories of reaction velocity, and their applications; particularly to the hydrolysis of esters, to aromatic substitution, to polymerization, and to ring closures. Equilibrium constants for acidic dissociation, for ring closures, and for reversible oxidation-reduction processes are also considered briefly.

This volume, like the first, is well printed and produced. But it is tediously written, it contains many infelicities of translation, and it gives far too much prominence to out-moded and incorrect theories. Its treatment of electrophilic aromatic substitution is particularly confusing and disordered. An attempt is made to contrast the qualitative electronic theory with the quantum-mechanical treatment attributed to Wheland and to Seel. It is stated, for example (p. 800), that the latter theory "makes unnecessary the assumption of postulated hypothetical effects". The reviewer considers that the author has appreciated incompletely not only the part played by factors of polarizability in the former theory but also the extent to which the "hypothetical effects" are concealed in the arbitrary assumptions of the latter. The reader will not be helped by Prof. Hückel's discussion of the former theory through the introduction of a "general effect", which deactivates for electrophilic substitution, but is identified strangely with Wheland's "polarization effect" and with Ingold's "inductometric (*sic*) effect".

Taken as a whole, the reviewer believes that these volumes will not generally be found useful by chemists familiar with other works available in the English language. P. B. D. DE LA MARE

AMERICAN MARINE LIFE

The Underwater Guide to Marine Life

By Carleton Ray and Elgin Ciampi. Pp. xiii+338+16 plates. (London: Nicholas Kaye, Ltd., 1958.) 30*s*. net.

THIS book about life in American coastal waters first appeared in the United States in 1956 and one wonders why an English publisher should have thought it suitable for the English market. Perhaps he is not aware that relatively few of the species described are to be found in European seas and that this book is of very limited interest to skin-divers (for whom it is primarily intended) on the eastern side of the Atlantic. His advertisements, one of them in a popular journal widely read by sub-aqua club members in Britain, certainly do not make any mention of this and in consequence are misleading.

The book, printed in the United States, is beautifully produced and attractively illustrated with many drawings and photographs, in both colour and black and white. It is true that the coloured drawings are sometimes not quite correctly tinted, but they are reasonably accurate in outline and will serve for identification, if not always for the species at least for the group. The preliminary chapters give an elementary account of the environment and of the general biology of the sea. The chapters on the techniques of underwater swimming and photography are too short to be really useful and the space they occupy could, with advantage, have been devoted to expanding the sections on plant life, and on the invertebrates which receive all too brief a treatment. The section on fishes occupies about half the book and is the most valuable portion of it. The final chapter deals briefly with marine reptiles and mammals. Apart from some minor errors of no great significance the book is accurate and well written, and should adequately serve its purpose as an underwater swimmer's guide to life on both coasts of the United States, especially the warmer parts. It should be very useful, too, to anyone visiting the magnificent marine aquaria and oceanaria of that country. D. P. WILSON

THE SOUTH AFRICAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

By Dr. S. M. NAUDÉ
President

WHEN he was called upon in 1944 by the Prime Minister of South Africa, the late General Smuts, to draft legislation for the promotion of scientific research in the Union of South Africa, Dr. B. F. J. Schonland had the advantage of being able to study the successes and failures of a number of official research organizations both within the Commonwealth and in other countries, notably the United States. The basic Act under which the South African Council for Scientific and Industrial Research came into being in 1945 thus reflects many of the best features of research bodies in existence at that time. The South African Council for Scientific and Industrial Research has now functioned for some thirteen years, and, looking back, we are in a position to assess the success of that early planning.

One of the most important features insisted upon by Dr. Schonland, who afterwards became the first president of the Council for Scientific and Industrial Research, was that while adequate provision should be made for Parliamentary control, the day-to-day administration should be free of direct control by any Government administrative department. This was achieved by the establishment of a council of nine members (later increased to sixteen) appointed by the Governor-General on the basis of their personal reputation and achievement as leading men of science in the technical departments of the Government service, the universities and industry. The Council is responsible directly to the Minister of Economic Affairs, who in turn answers to Parliament, but the annual budget is subject to Treasury approval. In staff matters the Council is not bound by the regulations of the Public Service Commission, but in practice follows them closely. Over the years the Council has been reasonably successful in retaining its freedom of action, though from time to time it has had to resist pressure from departmental administrators.

Another important feature of the organization of the South African Council for Scientific and Industrial Research is that, as in the case of the Canadian National Research Council, the president is at the same time chairman and chief executive officer. This ensures on one hand that the policy of the Council is carried out expeditiously and, on the other, that no decision is taken without full cognizance of the administrative problems involved. As the Council normally does not meet more than three times a year, routine and urgent matters are dealt with by the president with the assistance of an executive committee the decisions of which are subject to ratification by the full Council. On the administrative side, the president is assisted by two vice-presidents, who attend Council meetings but have no vote. This arrangement places the president in a powerful position; but in practice it has worked extremely well to provide effective and purposeful execution of a policy laid down by the country's leading scientists, industrialists, educationists and technical administrators.

The terms of reference of the South African Council for Scientific and Industrial Research, covering the promotion of scientific research in general, are very wide, but they exclude agricultural research, which is the responsibility of the Department of Agriculture, and research in the social sciences, for which there is a separate council. In practice, demarcation between different fields of research is often artificial, and the Council co-operates closely with these bodies in such fields as industrial psychology and the industrial use of agricultural products which do fall within the Council's sphere of activities. In the absence of a separate body to deal with medical research, this, too, is the Council's responsibility, and, since 1956, it has also been responsible for the statutory functions of the former Standards Council, including the administrative control of the South African Bureau of Standards.

Policy

After detailed study of the conditions existing in the Union of South Africa at the close of the Second World War, the first Council decided that promotion of scientific and industrial research should be along four major lines:

(1) In order to provide the Government and industry with the basic facilities of modern scientific research, it would establish, equip and operate a limited number of national laboratories for both fundamental and applied research.

(2) It would offer inducement to industry to conduct its own research. This would take the form of remission of taxation of research expenditure, direct financial assistance to co-operative industrial research associations and the provision of facilities in its national laboratories for confidential research sponsored by individual firms.

(3) To ensure the rapid utilization of the results of research going on both locally and abroad, it would establish comprehensive liaison and information services, including a central scientific library and overseas offices.

(4) Finally, in order to ensure a steady flow of trained research workers, it would establish a system of postgraduate bursaries and research grants in the universities.

The fact that after some thirteen years of practical experience these still remain the corner-stones of the Council's policy bears testimony to the wisdom of this early planning.

Administration

The running expenses of the Council have risen steadily year by year and at present are of the order

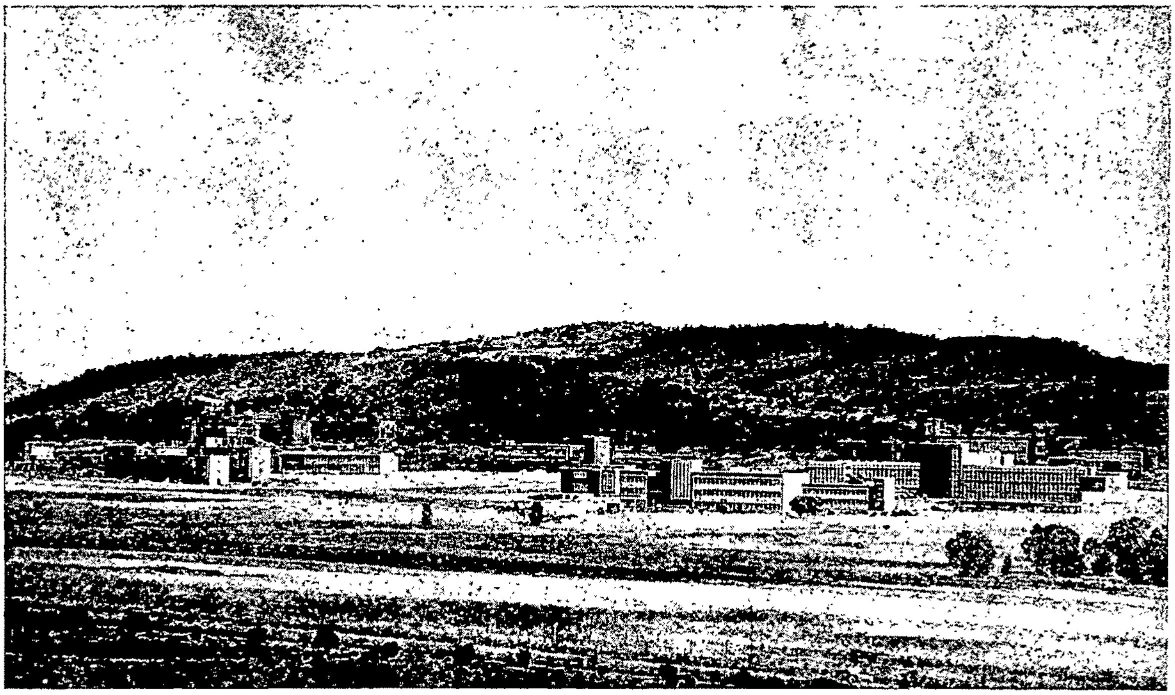

Fig. 1. New buildings at Scientia, the research centre of the South African Council for Scientific and Industrial Research

of £2,450,000 a year. Of this, the Parliamentary grant accounts for approximately £1,760,000, the remainder being earned by way of remuneration for investigations carried out for industry, fees and grants from other sources. The Council's assets in the form of capital equipment amount to a total of about £1,800,000, while the current valuation of its buildings stands at £1,122,000. The latter figure represents approximately one-third of the current building programme which is expected to be completed in the course of the next few years.

At the time of its establishment in 1945, the Council had the greatest difficulty in recruiting trained research workers, for even in the universities little active research was in progress. However, a small nucleus of enthusiastic young scientists was recruited, and several of them were sent for periods of up to two years for specialized training in research institutions in the United Kingdom, the United States and, later, Europe. Around this nucleus it has been possible to build the permanent staff of the Council, which now numbers a little less than 2,000, of whom approximately 550 are graduates. The average age of the staff is thirty-one years, and the number of women members is just short of 25 per cent. It is interesting to note that, although vacancies are widely advertised overseas, it has proved possible to recruit the great majority of scientists in South Africa. Throughout the thirteen years of its existence the total number of research workers recruited overseas has not exceeded fifty.

The recruitment of adequately trained staff, however, still remains one of the principal problems with which the Council has to contend. Apart from the general programmes aimed at increasing the output of research workers from the universities, about which more will be said later, two specific training programmes have been adopted. The first of these, known as the Overseas Directed Research Bursaries Scheme, is aimed at increasing the supply of trained research workers in fields in which the shortage is particularly acute or for which no adequate training facilities exist in South Africa. Under this scheme, young graduates are awarded bursaries of £500–£1,000 per annum plus a travel grant to enable them to study a subject designated by the Council. The bursaries may be renewed from year to year on the recommendation of a referee, usually a senior member of the Council's staff, to whom the bursar is required to report at regular intervals. The bursar must undertake to return to South Africa on completion of his study. The other is an undergraduate scheme whereby promising students are granted bursaries according to their needs to enable them to attend full-time degree courses at a South African university. In return, they are required to sign an undertaking to accept employment with the Council for a number of years, depending on the total amount of the grant.

Standardization

One way in which the South African Council for Scientific and Industrial Research differs from similar organizations in other countries is that it also has responsibilities for the promotion of standardization in industry. Originally this was the responsibility of a separate Standards Council, which also operated extensive laboratories for testing and investigations aimed at the improvement of industrial processes. In 1956, however, it was decided to abolish the Standards Council and transfer its functions to the Council for Scientific and Industrial Research. The reason for the change was that research and standardization may be regarded as complementary means of promoting industrial development, and the work could be most effectively co-ordinated by a single controlling authority.

The existing South African Bureau of Standards was retained as the instrument for giving effect to the Council's policy in regard to standardization and is now operated as one of the national laboratories. The methods whereby standard specifications and codes of practice are drawn up in consultation with manufacturers, consumers, government departments and other interested bodies are similar to those adopted elsewhere, but it is worth mentioning that the work of the committees responsible for drawing up specifications is greatly facilitated by being able to draw on the resources not only of the technical staff of the Bureau but also of the Council's research laboratories.

The adoption of all specifications issued by the Council is entirely voluntary, except where the health or safety of the public is concerned or where gross malpractice is taking place. In such cases the Minister of Economic Affairs may declare a particular specification compulsory.

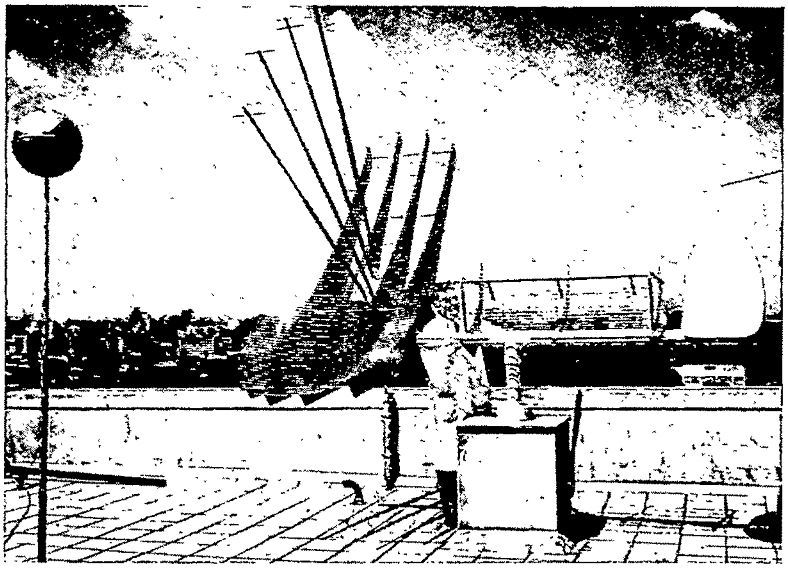

Fig. 2. Antenna display used by the South African National Telecommunications Research Institute in Johannesburg for research into the mechanism of lightning discharges

Linked with the preparation and issue of specifications and codes of practice is the standardization mark scheme, whereby a manufacturer producing articles in accordance with the requirements laid down in the specification may seek permission to apply one of the Bureau's marks to his product. The mark is protected by law, and quality is maintained by a regular system of inspection, sampling and testing in the Bureau's laboratories.

A further important service provided in the standards laboratories is general test work for consumers, public bodies and government departments. Normally, work which can be handled by private consultants and analytical laboratories is not accepted, but tests are undertaken for purposes of arbitration, together with a certain amount of forensic investigation on behalf of the police.

The services which the Bureau of Standards has been able to render industry have played a big part in the industrial development of South Africa. The expansion of our industries has proceeded largely by the introduction of established industrial practices and other adaptations to suit local conditions. Here the Bureau has been able to give a great deal of assistance by means of its testing facilities, by which it has been able not only to help manufacturers to procure raw materials and components against recognized specifications but also it has enabled them to assess the quality of their finished products and to compare them with equivalent products manufactured in other countries.

Research Laboratories

There are nine national research laboratories which conduct broad programmes of research, both fundamental and applied, aimed at providing the scientific information essential to the efficient utilization of the natural resources of South Africa. The National Chemical Research Laboratory, for example, has on its research programme a number of research projects which relate to raw materials or potential raw materials for South African industry. The National Physical Research Laboratory is responsible for maintaining South Africa's basic standards of physical quantities such as the units of measurement, heat, colour, sound and electricity; and is equipped to deal with specialized problems which require the use of physical techniques such as X-ray diffraction, electron microscopy, mass spectrometry and high-energy radiation. The problems involved in overcoming the critical shortage of housing at the end of the Second World War, together with those associated with the massive migration of native labour into urban areas to serve industry, led to the establishment of the National Building Research Institute, while the establishment of a large State-supported National Institute for Personnel Research to conduct research in the field of industrial psychology is a reflexion of South Africa's unique problems of man-power and human relations. This Institute developed out of research undertaken during the War for the Armed Services, as did the National Telecommunications Research Institute, which conducts research into radio propagation problems. Of more recent establishment are the National Institute for Road Research, the National Nutrition Research Institute, the National Mechanical Engineering Research Institute and the National Institute for Water Research.

The programmes of these laboratories are drawn up with the help of advisory committees and project sub-committees which advise the Council on the assignment of priorities. In recent years some of these advisory committees have been replaced by specialist advisers, who periodically investigate and report on the research programmes of sections of the laboratories. This system shows great promise, as it is at once less cumbersome and more effective than the committee system.

In addition to their normal research programme, these national laboratories perform a function similar to that fulfilled in the United States by the independent applied research foundations such as Battelle and the Mellon Institute. They undertake confidential research on a contract or fellowship basis for industrial sponsors, who may be single firms or groups of firms. In recent years this work has assumed considerable importance and provides a substantial proportion of the Council's operating revenue.

In certain instances the research staff are permitted to spend up to 30 per cent of their time on 'personal interest' projects and, as is to be expected, these often result in research of outstanding quality with practical implications which could not be foreseen when the projects were initiated.

Research in Industry

However, it is the policy of the Council to persuade industry to undertake its own research wherever possible. In a relatively newly industrialized country like South Africa, research on a worth-while scale needing elaborate and often expensive equipment and the services of highly trained scientists is generally beyond the means of individual firms; it is therefore essential that research of this kind should be organized on a group basis. To achieve this, the Council adopted a research association scheme similar to that developed by the Department of Scientific and Industrial Research in the United Kingdom.

To date, five associations, covering the leather, paint, fish processing, sugar milling and wool textile industries, have been formed. They are financed by annual subscriptions guaranteed for a minimum period of five years by the majority of firms in the industry concerned, matched by an approximately equal grant from the Council for Scientific and Industrial Research. Industrial contributions not guaranteed for the full period of five years also earn a Council subsidy but on a less generous scale. These industrial research associations are registered under the Companies Act as non-profit companies and are managed by boards of control on which the industrial contributors have majority representation. The research programmes are confined mainly to directed research problems of common interest to member firms, and to the solution of technological problems which arise in the day-to-day operations of individual factories.

An important feature of the research association scheme in South Africa is that all the associations are located at universities, one at the University of Cape Town, two at Rhodes University in Grahamstown, and two at the University of Natal in Durban. The directors have been accorded the status of professor by the universities concerned, and a close and fruitful relationship has resulted. All five associations have now run out of their first or second five-year guarantee periods, and the measure of their success may be judged by the fact that industrial contributions are still increasing both in number and amount.

Information and Liaison Services

Scientists and engineers throughout the world are slowly—perhaps too slowly—coming to realize that progress in science depends upon the intelligent solution of problems in the field of scientific and technical information. These problems are aggravated in a country in which centres of population are separated by great distances and in which there are no great libraries such as in Europe or North America. Whereas in older countries the main problems are concerned with making resources of scientific and technical information available to the users, in South Africa the more immediate need is to build up these resources.

One of the Council's first actions was thus to establish an advanced central scientific library to serve not only its own staff but also research workers throughout South Africa. A feature of this library is a very large collection of pamphlets and reports, each of which is fully 'processed'.

Associated with the library is an information service. This includes a technical and bibliographic inquiry service which is able to draw on the written word and the accumulated experience of scientists and engineers in the Council's laboratories. This is backed up by the Council's scientific liaison services in London, Washington and Cologne, through which the scientist in South Africa can draw on the resources of the great libraries of Europe and North America or get into direct touch with co-workers in other countries. There is a translation service, and other activities include the compilation and publication of the "Catalogue of Union Periodicals" and various scientific directories.

The Council shares with the Department of External Affairs the Government's responsibility for maintaining international relations in science. The Council's scientific liaison officers in London, Washington and Cologne are accorded the status of attachés to the Union's diplomatic missions in their respective areas and, in addition to reporting on the latest developments in the field of science, act as scientific advisers to the heads of the missions concerned. On behalf of South Africa, the Council adheres to the International Union of Scientific Unions and provides the secretariat for the South African national committees of its affiliated unions. It has, for example, been extremely active in organizing South Africa's participation in the International Geophysical Year.

University Research

The Council early realized that, if the new industries which had grown up during the Second World War and the new research organizations which had been established soon after it were to be adequately staffed, it would be necessary to augment the supply of graduates with advanced degrees from the universities. Unfortunately, South African universities have not been generously endowed by private individuals, industrial corporations and benevolent foundations as is often the case overseas, and in earlier years there was little demand for scientists trained in research. Consequently, most of their efforts were confined to undergraduate teaching and it was difficult for them to retain graduates and build up postgraduate schools. On its establishment, the Council took over the functions of the defunct Research Grant Board as the principal agency for the distribution of funds made available by the Government of South Africa for the promotion of scientific research in the universities, and immediately pressed for a substantial increase in the appropriation for this purpose. Increasing sums are being distributed in the form of bursaries to train postgraduate students in research techniques, to pay for assistants for more senior workers in their researches, for grants towards the running costs of specific programmes, for the purchase of major items of equipment not normally available in university laboratories, and for grants to assist in the publication of completed research.

The allocation is made by a series of selection committees on the basis of individual applications, but the funds are made available in the form of block grants to the universities, which are required to administer them. The Council has up to the present resisted requests from some of the universities for uncommitted lump sum grants rather than individual grants, because it feels that the limited funds available can be expended to the best advantage only on the basis of individual projects considered by a single authority which is in a position to assess the merits of each application in relation to others received from different universities. The universities are, however, strongly represented on all the selection committees.

Medical Research

The Council operates no laboratories of its own for medical research, but, on the advice of its Committee for Research in the Medical Sciences, makes a substantial financial contribution to work in this field.

An annual grant is made to the South African Institute for Medical Research and, in addition, the Council supports some twenty-one small units, groups and major projects in medical schools and hospitals in various parts of the country. The Council's approach in this case has been to single out particular research workers who have already established names for themselves in existing institutions and give them adequate facilities to continue and expand their work. In most cases the scientist continues to hold his appointment in the institution concerned, but the Council supplies additional staff to work under his direction and provides funds for running expenses and any equipment he may need. In this way the Council is assured that any project which it decides to support in the medical field will be led by an experienced and enthusiastic research worker who has already shown himself capable of producing results. On the other hand, should the project later prove to be unprofitable, there is no difficulty in closing it down. At present the Council supports research into the following subjects: amœbiasis, anæsthetic deaths, bilharzia, the biological effects of atomic radiation, the cardio-pulmonary and cardiovascular systems, degenerative diseases and the problems of aging, dental diseases, endocrinology, heart diseases, human biochemistry, nutrition (four separate units each with a different approach), pneumoconiosis, the reactions of the skin to sunlight, tuberculosis and virus diseases (two units).

It is interesting to note that evidence laid before the du Toit Commission, which was appointed by the Government to recommend a future policy for medical research in South Africa, was overwhelmingly in favour of retaining and expanding the present system under the general control of the Council for Scientific and Industrial Research instead of establishing an independent council for medical research. The findings of this Commission await consideration by the Government.

Achievements

It is not easy to assess the value of research, for its results can seldom be expressed in units which can readily be understood. There are, however, a few yardsticks which give at least some idea of what has been achieved.

One of these is publication. Some 800 scientific papers have now been published by staff members in the laboratories of the Council for Scientific and Industrial Research, and 300 have come from medical research units of the Council. To these must be added a further 550 which have flowed from the recipients of bursaries and grants from the Council.

Another yardstick, one which perhaps appeals most to the business man, is finance. We have not attempted to arrive at an exact estimate of the monetary value of the work we have done; this would be impossible, but our rough calculations convince us that actual savings brought about as a result of work done to date in our laboratories have more than covered the total amount spent by the Government on the Council for Scientific and Industrial Research, including the cost of buildings and equipment. As these savings have been brought about for the most part within the past few years as results began to flow from the laboratories, it is obvious that the annual savings will far exceed the annual costs of running the Council. Indeed, we estimate that the measurable savings to South Africa next year will be approximately seven times our parliamentary grant. As a concrete example, we could quote the case of research undertaken by the National Building Research Institute into the design of school buildings on behalf of the Transvaal Provincial Administration. The cost of this investigation was £20,000, and the cost of four of the schools in which the results of the research have been applied within the past two years amounted to £112,000 less than the Education Department would have had to pay had they been built to the old standard pattern with inferior accommodation and facilities. Several other examples, equally impressive, could be quoted.

Discoveries and inventions by the Council's staff are patented only if it is considered that the patent will aid in development of the inventions and thus in application of the results of research. Applications have nevertheless been filed in respect of some thirty-seven inventions. Revenue in the form of licence fees from the few inventions that are now being exploited at present amounts to about £50,000 a year and is increasing rapidly. This is ploughed back into research. Among the more successful of such inventions are the 'tellurometer', which is now being manufactured in South Africa and finding wide application for distance measurement in many parts of the world, and a water desalting process which is being used in the largest plant of its kind in the world on the new Orange Free State goldfields.

These, however, are but the more material results of research due to the Council for Scientific and Industrial Research. Of far greater importance in the long run are the immaterial benefits such as improved health and human comfort, greater productivity in industry and ultimately, we hope, a more contented people. In the universities we now see research being tackled with enthusiasm where practically no research was done before, and in industry we now attempt to solve our own problems where previously we were content to accept without question the dubious applicability under local conditions of technical knowledge imported from overseas. In short, South Africa is becoming conscious of the immense benefits to be derived from the intelligent use of science. This, we claim, is in no small measure due to the activities of the Council for Scientific and Industrial Research.

THE NUCLEAR RESEARCH CENTRE, GRENOBLE

THE Nuclear Research Centre at Grenoble, a further establishment under the control of the French Atomic Energy Commission, was officially opened on January 26.

The creation of this Centre under the French Government's general policy of decentralization is a further step towards increasing the research facilities of the French Atomic Energy Commission.

The Grenoble Centre (C.E.N.G.) will operate in close liaison with the city's University, which possesses laboratories in several branches of science of considerable repute (electrostatics and metal physics, science of low temperatures, fluid mechanics, chemistry, electronics, and so forth) plus excellent engineering faculties, and in particular a special atomic engineering course.

The director of the Centre, Prof. Louis Néel, member of the Paris Academy of Sciences, is also director of the Ecole Nationale Supérieur d'Ingénieurs of Grenoble and the Electrostatics and Metal Physics Laboratory of the Centre National de la Recherche Scientifique.

The first construction programme for the Nuclear Research Centre at Grenoble was completed in two years, on an extensive site close to the city. The programme comprised a number of modern laboratories suitable for a wide variety of research work, two large hangars of industrial type for noisy or bulky experiments, workshops and general services buildings. Facilities comprise the reactor *Mélusine* and a group of five electrostatic accelerators. *Mélusine* owes its name to a water sprite, which according to local tradition haunted the caves of Sassenage, near Grenoble. It is a 20 per cent enriched uranium pool reactor, of 1,200 kW. power, neutron flux 10^{13} neutrons/cm.^{2}/sec. It was built by the French industrial group "Indatom", and the fuel elements are obtained from the United States.

The accelerator building will be equipped in April with one fast neutron generator and four electrostatic accelerators (two ion accelerators, two electron accelerators) with potentials ranging between 600 kV. and 1·4 MV. Their special characteristic is a very high particle current (4 m.amp. with the 1·4 MV. ion accelerator) obtained with a type of electrostatic generator designed in one of the laboratories of the University of Grenoble, and built by the S.A.M.E.S., a company specializing in electrostatic machines.

The research programme of the Grenoble Centre is distributed over a number of 'laboratories'. Research in physics includes the activities of the solid state physics laboratory, where the effects of neutron bombardment on matter are studied, in close conjunction with the low-temperature laboratory, ex-

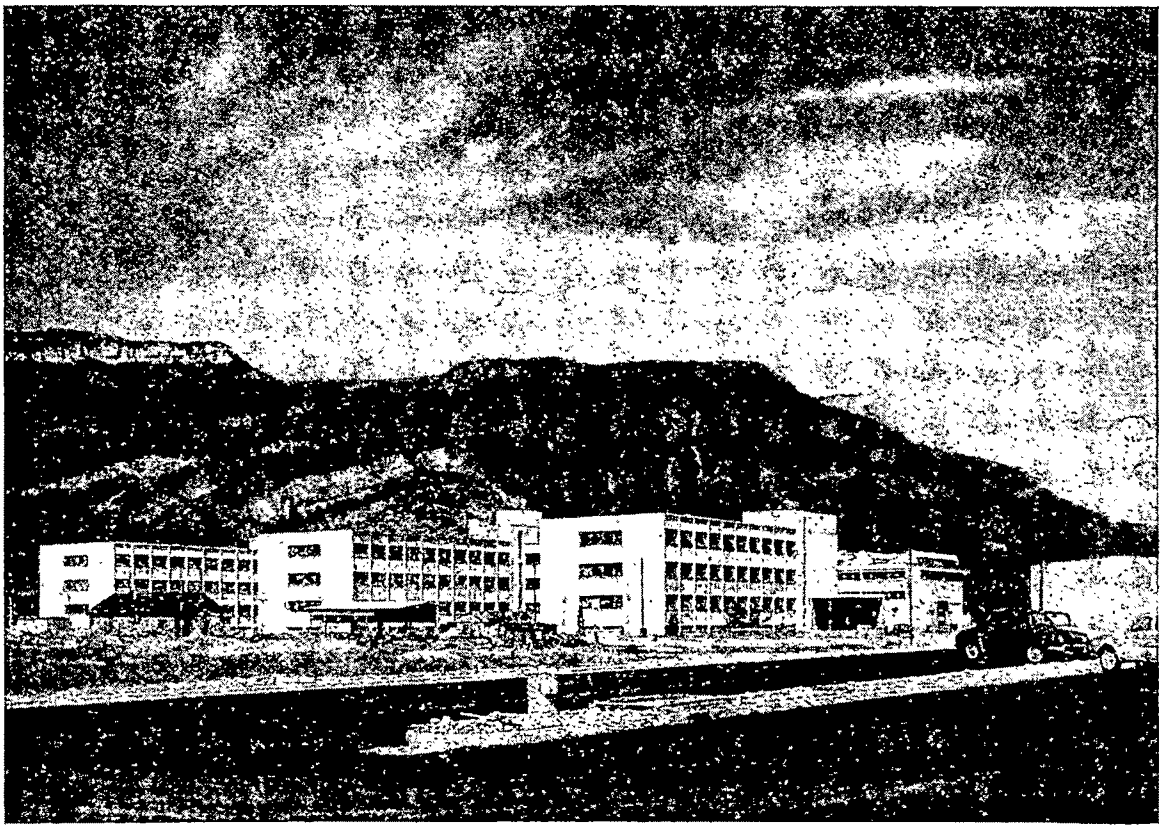

Fig. 1. Laboratory buildings at the Centre d'Etudes Nucléaires de Grenoble

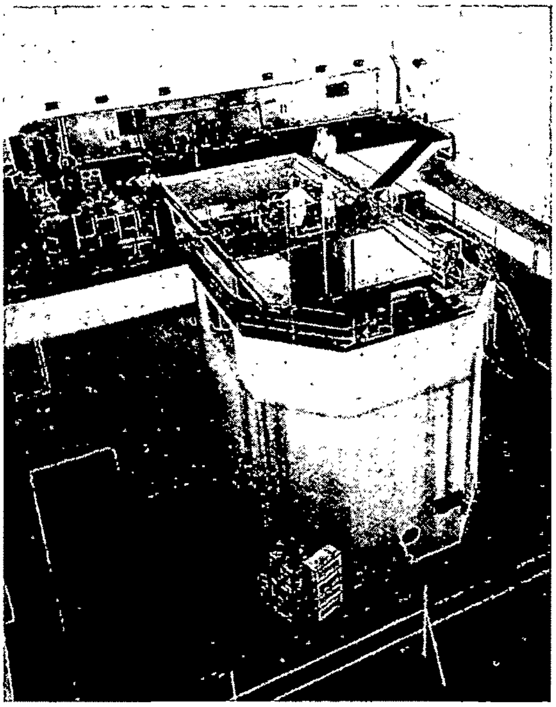

Fig. 2. Swimming pool reactor *Mélusine*

tending this research into the range of 20–900° K., and also the work of the neutron diffraction and magnetic resonance laboratories.

A radiochemistry laboratory has been installed in the Centre by the French Petroleum Institute, while the chemistry of solids laboratory is working on the production of a uranium compound for nuclear fuel elements.

There are, of course, also electronic laboratories, others for the study of applications of radioelements, and biology and nuclear physics laboratories, and also the thermal exchange laboratory, where heat exchanges with liquids in a reactor are studied.

The Centre's research programme is prepared by a scientific committee composed of six representatives from the Atomic Energy Commission and six professors from the University of Grenoble, who are scientific advisers to the Centre. This ensures the essential co-ordination with the programmes of other Atomic Energy Commission research centres.

As from January 1, the research work of the Centre is employing 300 persons. Construction is continuing, and the total staff by the end of 1961 will be 800.

In order to help in obtaining the required number of staff, the Centre collaborates with the organizations entrusted with the training of technicians at all levels. It is also pleasant to note that the Centre is situated in a region that is both industrial and of tourist interest, in the heart of the French Alps, and therefore considered particularly attractive by young technicians.

OBITUARIES

Prof. A. H. Gibson

PROF. ARNOLD HARTLEY GIBSON, emeritus professor of engineering in the University of Manchester, died on February 16 at the age of eighty.

Those who have read Prof. Gibson's monograph on Osborne Reynolds will realize how much 'A. H. G.' admired his own teacher. That he shared some of Reynolds's versatility is clear from the fact that although he will best be remembered for his contributions to hydraulics, he also did significant work in structures (the 'circular-arc bow girder') and in applied thermodynamics (many papers on internal combustion engines and heat transmission). At one period he was simultaneously a member of the Air Ministry Engine Research Committee and of the Severn Barrage Committee.

In hydraulics, his investigations ranged from the behaviour of bodies floating in vortices to river models; from water hammer in pipes to the effect of bridge piers on tides; from centrifugal pumps to the interaction between passing vessels. His famous treatise "Hydraulics and its Applications" was published in 1908; the fifth edition appeared in 1952: he was then seventy-four years old and told me how much he would have liked to rewrite it, but he feared that in that case the price would have been beyond the reach of many for whom the book was intended. The chapter on scale models which he added is probably his last published work.

His writings have an unfailing clarity and directness, virtues which were also very evident in the unaffected elegance of his lectures. He knew just when to stop before confusing the issue.

Gibson's reports on the Severn tidal model (1933) have rightly been described as 'monumental' (an adjective which caused him some amusement). The scope and variety of the experiments—the trials on bed materials, the introduction of silt and the representation of the coagulating effect of the salts of the sea, together with the study of the tides and the bore—remain unsurpassed in this field, even allowing for the later growth in the size of models. His investigations of the Severn and other estuaries revived British interest in the possibilities of scale models as an aid to the design of river and harbour works and led to the creation by the Department of Scientific and Industrial Research of the Hydraulics Research Station at Wallingford.

Generations of students have held him in affection as well as admiration, and one reason for this is to be found in his own interpretation of the duties of a professor. His aim was to inspire and never to 'spoon-feed'. He not only believed that he ought to lecture to each year but also he enjoyed doing so. The course of twenty or twenty-five lectures which he delivered to students in their first term at Manchester, covering a wide field of applied mechanics, brought immediate contact, and this was renewed in the second and third years. At one time or another he lectured on almost every subject in civil and mechanical engineering. Yet in addition he took his full share in the general work of the University in Senate, faculty and committees and maintained his output of important original papers.

The fact that he was able to do so much can be partly explained by his gift for making quick decisions. As Prof. J. A. L. Matheson has written elsewhere, "Gibson was a swift and brilliant intuitive worker. He could recognize a problem, build the apparatus, carry out the experiments and write up the results at a quite astonishing speed . . .". He was equally happy in guiding and encouraging his colleagues and research students. When he saw you baffled, he would blow a ring of tobacco smoke and say, "If I were you, I would try . . .".

Gibson enjoyed good books (which he read with a speed like that of his own writing) and works of art. He detested the pompous and the shallow equally. He sought no honours, but those intimate with him saw that he was made happy and proud by such distinctions as the Ewing Medal of the Institution of Civil Engineers and the honorary degrees of LL.D. conferred upon him by St. Andrews and Manchester. It is probably true, however, that the D.Sc. which he won at Manchester fifty years ago remained his favourite.

Naturally, his name is linked most prominently with the Beyer chair in his Alma Mater (1920–49), but he spoke with great affection of his period in Dundee as professor of engineering in the University of St. Andrews (1909–20, interrupted by service during the First World War in the Army and at Farnborough).

Perhaps no truer or more fitting tribute could be paid to 'A. H. G.' by those of us who had the happy experience of being his students and colleagues than to say that we feel the same veneration for him as he felt for Osborne Reynolds. JACK ALLEN

Prof. G. V. Douglas

GEORGE VIBERT DOUGLAS died suddenly in Toronto, Canada, on October 8, 1958, at the age of sixty-six. From 1932 until his retirement in 1957 he was Carnegie professor of geology at Dalhousie University in Halifax, Nova Scotia.

Prof. Douglas was born in Montreal in 1892. At McGill University he studied under F. D. Adams, but this training was interrupted by the First World War and he went overseas in 1915. He served in France and Flanders with the 17th Battn. Northumberland Fusiliers and, for a short time, with the Royal Engineers. He was awarded the Military Cross and mentioned in dispatches. He returned to Canada in 1919. He graduated from McGill in 1920 and received his M.Sc. degree in 1921.

He spent the next two years in the Antarctic as geologist with Shackleton's last expedition. While working up the results of the expedition, he was able to work in the University of Cambridge. This was followed by further work at Harvard University, where he held a part-time post as instructor under Daly. In 1926, he became chief geologist for the Rio Tinto Company—at first in Spain and later on the Rhodesian Congo Border concession. In 1932 he left the Rio Tinto Company to take up the post at Dalhousie which he held for the remainder of his active life.

Prof. Douglas was a notable factor in the lives of a whole generation of students. Undoubtedly his greatest influence arose from his ability to inspire enthusiasm and to encourage the student to do the best of which he was capable. A secondary influence was his own wide-ranging interest, and one recalls vividly the stimulus of an afternoon at his home, when ideas (some good, many otherwise, no doubt) flew like shuttlecocks as the teacher encouraged his students to exercise their wits. Ideas strongly held often plunged him into controversy but, though many disagreed, there were none who did not admit his courage and integrity.

He is survived by his wife, two daughters and two sons, and by his sister, Dr. A. V. Douglas, of the Department of Astronomy, Queen's University, Kingston, Ontario. G. C. MILLIGAN

NEW FELLOWS OF THE ROYAL SOCIETY

AT a meeting of the Royal Society on March 19, the following were elected to fellowship of the Society:

DR. G. H. BEALE, senior lecturer in genetics in the University of Edinburgh (Institute of Animal Genetics), distinguished for his researches on the genetics of flower pigments and on nucleus–cytoplasm relations in *Paramecium*.

PROF. F. BERGEL, professor of chemistry in the University of London, at the Chester Beatty Research Institute of the Institute of Cancer Research, Royal Cancer Hospital, distinguished for his work in synthetical organic chemistry in the field of vitamins and drugs.

DR. ANN BISHOP, director of the Medical Research Council Group for Research in Chemotherapy, at the Molteno Institute of Biology and Parasitology, Cambridge, distinguished as a protozoologist and especially for her work on the malaria parasite and its resistance to drugs.

PROF. G. E. BLACKMAN, Sibthorpian professor of rural economy in the University of Oxford (Department of Agriculture), distinguished for his research work on the ecology of wild and cultivated plants and on weed-killers.

PROF. H. BONDI, professor of applied mathematics in the University of London (King's College), distinguished for his contributions to cosmology, astrophysics and other branches of theoretical physics.

PROF. J. M. CASSELS, professor of experimental physics in the University of Liverpool, distinguished for his studies of high-energy nuclear physics using particle-accelerating machines.

PROF. A. R. CLAPHAM, professor of botany in the University of Sheffield, distinguished for his research upon many important aspects of ecology and taxonomy, especially those relating to British plants.

DR. F. H. C. CRICK, member of the staff of the Medical Research Council Unit for Research on the Molecular Structure of Biological Systems at the Cavendish Laboratory, Cambridge, distinguished for his contributions to molecular biology.

MR. G. B. R. FEILDEN, director of research, Ruston and Hornsby, Ltd., Lincoln, distinguished for his application of scientific principles to the development and design of industrial gas turbines.

DR. D. W. W. HENDERSON, director of the Ministry of Supply Microbiological Research Establishment, Porton, Wiltshire, distinguished for his work on aerosols and the pathogenesis of air-borne infections.

Dr. R. D. Keynes, lecturer in physiology in the University of Cambridge, distinguished for his work on ionic movements in nerve and muscle and on the origin of the discharge in electric fish.

Prof. R. J. W. Le Fèvre, professor of chemistry, and head of the School of Chemistry, in the University of Sydney, distinguished for his studies of the physical properties of organic compounds.

Dr. B. H. Neumann, reader in mathematics in the University of Manchester, distinguished for his contributions to the theory of groups.

Dr. S. R. Nockolds, reader in geochemistry in the University of Cambridge (Department of Mineralogy and Petrology), distinguished for his researches on the petrology and geochemistry of the igneous rocks.

Prof. W. C. Price, professor of physics in the University of London (King's College), distinguished for his contributions to chemical physics, especially to spectroscopy.

Prof. G. V. Raynor, Feeney professor of physical metallurgy and head of the Department of Physical Metallurgy in the University of Birmingham, distinguished for his research on the structure of metals and alloys.

Prof. O. W. Richards, professor of zoology and applied entomology in the University of London (Imperial College of Science and Technology), distinguished for his researches in entomology.

Dr. R. E. Richards, lecturer in chemistry in the University of Oxford (Physical Chemistry Laboratory), distinguished for his work on nuclear magnetic resonance and its application to chemical problems.

Prof. C. A. Rogers, Astor professor of mathematics in the University of London (University College), distinguished for his contributions to several branches of pure mathematics, particularly the geometry of numbers.

Prof. A. Salam, professor of applied mathematics in the University of London (Imperial College of Science and Technology), distinguished for his contributions to the theory of elementary particles.

Dr. R. Spence, chief chemist and head of the Chemistry Division, Atomic Energy Research Establishment, Harwell, distinguished for his work on the chemistry of radioactive elements, and for his leadership of the Chemistry Division of Harwell.

Dr. J. F. Tait, Worcester Foundation, Shrewsbury, Massachusetts, U.S.A., distinguished for his work on the hormones of the suprarenal cortex.

Mrs. S. A. S. Tait, Worcester Foundation, Shrewsbury, Massachusetts, U.S.A., distinguished for her work on the hormones controlling the distribution of salts in the body.

Dr. M. H. F. Wilkins, deputy director of the Medical Research Council Biophysical Research Unit, at the University of London (King's College), distinguished for his contributions to the development of reflexion and interference microscopy, and for his work on the structure of nucleic acids.

Prof. S. W. Wooldridge, professor of geography in the University of London (King's College), distinguished for his researches on the geomorphology of south-eastern England.

NEWS and VIEWS

The United Kingdom Atomic Energy Authority

The organization of the United Kingdom Atomic Energy Authority is to be changed as from July 1. Hitherto the Authority has been made up of three groups: the Research Group, the Weapons Group and the Industrial Group. The Industrial Group, which has become too large for convenient management, will now be divided into two: the Development and Engineering Group; and the Production Group. At the same time, the full-time technical members of the Authority will again assume executive responsibility for particular Groups, in addition to their functional responsibilities and general duties as members of the Board. Sir William Cook, with the title of Member for Development and Engineering, will be executive head of the Development and Engineering Group and will, in addition, retain corresponding functional responsibilities throughout the Authority. Sir Leonard Owen will have the title of Member for Production (Designate) and will be the executive head of the Production Group. Sir William Penney, whose appointment to succeed Sir John Cockcroft as the Member for Scientific Research has already been announced, will in addition become the executive head of the Research Group, while retaining his functional responsibilities for scientific research throughout the Authority. The appointment of a successor to Sir William Penney as Member for Weapons Research and Development will be announced later.

New Appointments

The following appointments have been made in the Research Group of the United Kingdom Atomic Energy Authority:

Mr. D. W. Fry, deputy director of the Atomic Energy Research Establishment, Harwell, to be director of the Atomic Energy Establishment, Winfrith (*Nature*, 182, 1129; 1958).

Prof. F. A. Vick, professor of physics in the University College of North Staffordshire (*Nature*, 166, 54; 1950), to be deputy director of the Atomic Energy Research Establishment, Harwell. During 1950–54 Prof. Vick was acting-principal of the University College of North Staffordshire. He is a member of the University Grants Committee.

National Research Development Corporation: Appointments

Mr. J. C. Duckworth has been appointed managing director of the National Research Development Corporation as from April 1 in succession to Lord Halsbury, who has been managing director since the formation of the Corporation in 1949 and is now going into industry. Mr. Duckworth, who is forty-two years old, took first-class honours in physics at

Oxford in 1938, and played a leading part in radar research and development during the Second World War. After the War, he was engaged in fundamental nuclear physics research at Chalk River in Canada and at Harwell, and was later in charge at Ferranti, Ltd., of development and design of the guidance and control system of the guided weapon now known as *Bloodhound*. In 1954 he joined the then British Electricity Authority with responsibility for the design, construction and operation of nuclear power stations, and is at present chief research and development officer of the Central Electricity Generating Board.

Mr. Dennis Hennessey has been appointed by the Corporation to a new post of deputy managing director. Mr. Hennessey, who was a former principal patents officer at the Ministry of Supply, joined the staff of the Corporation in 1950 at the age of thirty-eight and was made an executive member of the Corporation in 1956.

Government Research on Food Preservation

THREE research stations of the Department of Scientific and Industrial Research, all concerned with the preservation, storage, handling or protection of foodstuffs, will be transferred to the Agricultural Research Council on July 1. They are the Ditton Laboratory at Larkfield, Kent, the Low Temperature Research Station at Cambridge, and the Pest Infestation Laboratory at Slough. The agreement between the Council for Scientific and Industrial Research and the Agricultural Research Council—announced in the House of Lords by the Lord President of the Council, Lord Hailsham, on March 4—was made because the two Councils consider that Government research on food other than fish would be more effectively pursued under one authority. The staff in the three laboratories, numbering about 200, will be invited to transfer to the service of the Agricultural Research Council.

Agriculture at Aberdeen : Prof. J. R. Raeburn

DR. J. R. RAEBURN, recently nominated to the Strathcona–Fordyce Chair of Agriculture at Aberdeen, in succession to Prof. A. B. Stewart, who has been appointed director of the Macaulay Institute for Soil Research (see *Nature*, 181, 1105 ; 1958), was educated at Manchester Grammar School, at the University of Edinburgh and at Cornell University. His career has been one of widely varied experience in research, teaching and administration. He did practical farm work in Scotland during 1928–29, and was engaged in research at the Edinburgh Animal Breeding Research Institute during 1932–33, before proceeding to his doctorate at Cornell. During 1936–37 he had the unusual experience of serving at the University of Nanking under Prof. Buck, whose collection of information on the subsistence agriculture of Chinese peasants is unsurpassed in any other such country. The agriculture of African and Asian peasants has been one of Dr. Raeburn's principal fields of research and teaching during his tenure of the readership in agricultural economics in the University of London since 1949. He has travelled extensively and has been much consulted by the Colonial Office on the development of its agricultural policy. During the Second World War he served in the Ministry of Food as secretary of the Home Agricultural Supplies Committee, the duty of which was to plan the development of home supplies in such a way as to give the maximum release of shipping space. During 1938–39 and 1946–49 he was a research officer at the Oxford Agricultural Economics Research Institute. At an early age Dr. Raeburn was recognized as an outstanding figure in his own fields of research. His work combines extensive knowledge and experience with subtle and sympathetic understanding of the difficult problems of decision which every farmer has to face, and strong criticism of some unreliable methods of sampling used in obtaining agricultural economic information.

The Jodrell Bank Radio Telescope

IN replying on an adjournment debate in the House of Commons on March 4, in which Mr. R. E. Winterbottom and Lt.-Col. W. H. Bromley-Davenport had, while supporting the Committee of Public Accounts, pleaded for a more generous attitude from the Government in meeting the outstanding £140,000 on the Jodrell Bank Radio telescope, Mr. H. Nicholls defended the Government's attitude and, outlining the financial history in some detail, claimed that the Government from the first had given all the help it possibly could, within the limits of sound financial control, to this great project. Out of eight recent major university schemes costing more than £100,000 each which are being supported by the Department of Scientific and Industrial Research, three, including the Jodrell Bank project, had come under the ægis of the University of Manchester, and Mr. Nicholls did not think that the University had been treated ungenerously. The Government did not want to discourage the universities and scientists from embarking on similar projects which would place Britain in the lead in the future, but it must know on what the money was being spent before it was granted. It must also respect a second principle, that if the cost of any project is liable to be greatly increased, the Government department concerned must be kept clearly informed from start to finish and should agree to the extra expenditure before being held liable for it. Mr. Nicholls promised to report to the Lord President what was said in the House.

Transient Reactor Test Facility achieves Criticality

THE Transient Reactor Test Facility (*Treat*), a reactor designed to investigate the effect of extreme nuclear heat upon fast reactor fuel elements, achieved criticality at 23.30 E.D.T. on February 23 at the U.S. Atomic Energy Commission's National Reactor Testing Station, Idaho Falls, Idaho. The reactor, designed by the Argonne National Laboratory, can deliver a high-intensity, short-duration surge of nuclear energy without damage to the facility itself. The surge will result when a large number of atoms undergo fission in a short time and will cause intense heat to be generated in the sample being tested. The surge will be useful in simulating abnormal reactor operating conditions and will permit reactor designers to observe on a small scale the effect of such conditions on prototype fuel elements planned for fast reactors. The facility, which resembles a research reactor, is fuelled with uranium oxide uniformly dispersed in graphite. The graphite lsows down the neutrons produced by the fission of uranium atoms, enabling the neutrons to collide with other uranium atoms to continue the chain reaction. During the surge, the abnormal amount of heat generated in the fuel due to fission is transferred instantaneously to the graphite, which absorbs the released energy. As the graphite becomes heated, its efficiency in slowing down the neutrons decreases. Consequently fewer neutrons capable of producing fission are available, permitting the surge to be held to a safe level. For this reason, the reactor is said to have self-limiting operating characteristics.

Research in Tropical Medicine

The U.S. National Academy of Sciences–National Research Council is to organize a major survey of needs in the field of tropical medicine, under the direction of Dr. W. H. Wright, who recently retired as chief of the Laboratory of Tropical Diseases, National Institutes of Health. The survey will embrace the fields of infectious and parasitic diseases, veterinary medicine, and environmental hygiene. It will include surveys of disease problems in tropical and sub-tropical areas of significant importance to public health and to agricultural and industrial development; of funds expended for medical care and disease control; of financial support for research in medical and hygienic problems of the tropics; of fellowships, teaching programmes, and training facilities; of careers and incentives; of the impact of travel and migrations on tropical disease problems; of the importance of tropical medicine to the economy and man-power situation in the United States. On the basis of these findings it should be possible to assess the need for domestic, foreign and international measures to deal with the problems defined in the survey.

Scientific Linguists in the United States

An inquiry by the National Science Foundation into the knowledge of foreign languages possessed by American scientists indicates that 97,000 of the 127,000 on the National Register of Scientific and Technical Personnel during 1954–55 (probably more than half of all American scientists) possessed a knowledge of at least one foreign language, German being the commonest, and French coming next. In psychology and the earth sciences, proportionately greater numbers reported knowledge of French, Spanish and other Romance languages, but only about 1 in 50 reported a knowledge of Russian and fewer than 1 in 100 of Chinese.

Science Laboratory Technicians

The City and Guilds of London Institute and the Institute of Science Technology announce that they have taken important steps to rationalize their examinations and qualifications for science laboratory technicians. Hitherto, both Institutes have held such examinations, but in future there will be only one series, held by the City and Guilds of London Institute on behalf of both Institutes. The conduct of the examinations and their further evolution will be under the guidance of a joint advisory committee of both Institutes and the certificates awarded to successful candidates will bear the heading: "The City and Guilds of London Institute in conjunction with the Institute of Science Technology". Transitional regulations have been agreed to ensure that no student at present preparing for the examinations of the Institute of Science Technology suffers because of the new arrangements. The arrangements for the award of the Fellowship of the Institute of Science Technology remain unchanged.

Soddy's Cubic Equation Machine

Frederick Soddy was always looking beyond the borders of his main field of activity, and on several occasions he invaded mathematics. He took a great interest in locating circles within circles, and in calculating the radius of an inside circle he derived a cubic equation, which suggested the possibility of using a geometrical construction for solving the associated cubic equation. He thereupon made a machine with strings and pulleys which, when set with magnitudes derived from a cubic with numerical coefficients, would indicate the corresponding roots if they were all real. After the Second World War he made a machine with pivoted levers and scales which did the same operation without employing strings. In his will he provided for the exploitation of this machine, but this proved impracticable, largely because of the speed with which actual cubic equations can be solved with electronic computers, and his device required some calculations before it could be properly set. His attempt is, however, of some historical interest, and the model has been handed over to the Science Museum.

Applied Mathematics in the Soviet Union

Appreciation in the West of the substantial contributions made by Soviet scientists to the study of topics in applied mathematics, such as, for example, the mathematical theory of elasticity, has sometimes been delayed by linguistic difficulties; the summaries available give valuable indications of content, but not always of method. The American Society of Mechanical Engineers has secured a grant from the National Science Foundation which will enable the Pergamon Institute to translate the important periodical, *Prikladnaia Matematika i Mekhanika* (Applied Mathematics and Mechanics), and to publish it as a bi-monthly journal. The aim is to give an exact translation of the original papers, with editorial glosses or comment kept to a minimum. The present series begins with Vol. 22 (No. 1; 1958) of the original, which contains papers accepted during 1956 and 1957, so that translation and re-publication do not seem to have added substantially to the normal time-lag between acceptance and publication. The enterprise should prove of great value to mathematicians in Great Britain and the United States. The annual subscription is 35 dollars or £12 10*s*., and orders can be placed with the Pergamon Press in London or New York.

Educational Research

First launched some three months ago, this new journal contains information about educational research which should be of interest to practising teachers, local authorities, administrators and other educationists. The articles are particularly valuable because they indicate what may be accepted as established fact, what may reasonably be inferred, and the bearing of the topics referred to upon the day-to-day life of the school and the thought and practice of the teacher. The February issue of the journal (1, No. 2) describes the effects of size of class on teaching, differences between education in town and country, how children understand numbers, and compares the methods of teaching reading. The contributors include well-known educationists, including Sir Cyril Burt and Dr. C. M. Fleming. Future issues are to include articles on the teaching of modern languages; research in technical education; the gifted child; bilingualism; testing attainment; and children's vocabulary. The new journal is issued three times a year in step with school and college terms. It can be obtained from the publishers, Newnes Educational Publishing Co., Tower House, Southampton Street, Strand, London, W.C.2.

Grants to Students in Britain

A MEMORANDUM submitted by the National Union of Students to the Committee on Grants to Students set up by the Minister of Education and Secretary of State for Scotland under Sir Colin Anderson as chairman has now been published (pp. 28. London: National Union of Students, 1959). Its seventeen recommendations include the financing of awards entirely by the Government and administration by a central grant-awarding authority, or alternatively and as an interim measure, that the awards should be financed mainly by the Ministry of Education, with a proportion to be met from a pool to which all local education authorities should contribute. Awards should be given to those selected by universities for first-degree courses and for comparable courses in other institutions of higher education and the relevant authorities should be invited to review the standard set in 'closed' scholarship examinations. University authorities are urged to consider the practicability of establishing a clearing house system for dealing with university applications, and a review of the values of university scholarships and removal of their maintenance factor are also recommended. In the light of the university review an honorarium for State scholars should be agreed, while the system of supplementation by the Ministry should be ended and the numbers of State scholarships offered should be reviewed each year. Non-recurrent prizes gained in open competition during the course should be tenable without reduction of grant, and awards should also be granted on acceptance to students taking full-time or sandwich courses of degree study at technical colleges or courses recognized by the Ministry of Education as being of comparable status, and these awards should be assessed on the State scale for major awards. It is also recommended that awards should be made without reference to the parental income and that the values of awards should be reviewed every two years instead of every three years.

Graduates in British Industry

THE Information Division of the Department of Scientific and Industrial Research has issued under the title "Graduates in British Industry" (pp. iv+28. London, 1958) a short record of the main findings and applications likely to be of value to firms recruiting graduates, and also to graduates newly appointed to jobs in industry, of the two reports "Graduate Employment—a Sample Survey" and "Graduates in Industry" published by Political and Economic Planning. The record is illustrated with diagrams and the main pointers for management are summarized in the final section. The conclusions from the inquiry are also given concisely following eight short sections dealing with various aspects of the subject.

Atmospheric Temperatures

METEOROLOGISTS, aviators, and those concerned with the planning of air routes, often require information about the winds and temperatures which may be expected in different parts of the globe at various levels. Winds are usually more important, and the Meteorological Office published its Geophysical Memoir No. 85 some time ago to meet this urgent need. Now a companion Memoir, No. 101, has been published, giving temperature information for all parts of the Earth except those regions south of latitude 60° S., mainly at the standard pressure-levels 700, 500, 300, 200, 150 and 100 mb., which range from 10,000 ft. to 56,000 ft. approximately. The presentation involves variation with place, height and time, and is necessarily done graphically, but the nature of the variations is complicated by the variations in the tropopause-level. When any point is sometimes in the troposphere and sometimes in the stratosphere, the temperature variations are normally bimodal, that is to say, the distribution curve shows two peaks, one corresponding to tropospheric and the other to stratospheric events. In this case, special care must be taken in interpreting the data, and it is inevitable that the Memoir contains a great deal of information about the tropopause and its average movements. This, particularly, will interest the meteorologist. The sources of the data have been carefully listed; but a map showing the distribution of the observing points might have been a valuable guide to the extent to which it has been necessary to interpolate over various areas. For example, it has not been possible to include any data since 1952, and sometimes data from adjacent areas are taken for different years. This must sometimes cause apparent changes from place to place due to the different regimes which occur in different years, and there must be very few results from areas between 35° S. and 60° S. The present Memoir is welcome, but even though it has just appeared we shall look forward to a new edition, revised in the light of the very much greater volume of information obtained during the International Geophysical Year.

Assistance from the International Atomic Energy Agency

A PAMPHLET, "Technical Assistance" (pp. 16. Vienna: International Atomic Energy Agency, 1958), outlines the services available from the International Atomic Energy Agency, describing first the kinds of assistance, including fellowships and exchange visits, the provision of advice and information on nuclear energy problems and equipment, and secondly the fields in which member States can request assistance from the Agency. Those listed include library and documentation services; ore prospecting, mining and processing; the design, construction and management of nuclear research laboratories and centres; nuclear research; nuclear reactors; the use of radioisotopes; safeguards; and problems of health, safety and disposal of waste. Thirdly, rules and practices governing assistance are detailed.

Craters on the Moon

RECENT reports of a volcanic eruption near the lunar crater Alphonsus have apparently stimulated fresh experiments and speculation on the origin of these craters. Apart from the well-known meteoritic and volcanic theories, F. Benario suggested some years ago (*The Strolling Astronomer*, 7, 19; 1953) that a bursting bubble of gas could produce a crater of similar form. In a recent letter, Dr. A. G. Gaydon and R. C. M. Learner (*Nature*, 183, 37; 1959) showed photographs of crater-like formations produced by gas effusing through a light dry powder under vacuum. There appears to be some confusion between the two latter experiments, which are in reality quite different. In Benario's work, the sudden bursting of a gas bubble (in a slurry of plaster of paris, water, and 'Alka-Seltzer') was observed. In Gaydon and Learner's experiments, the crater wall was built up quite slowly by a continuous fountain of falling dust. The latter experiment is more related to volcanic action, but assumes a fall of dust or ash, as at Pompeii, rather than a flow of molten lava. A flow of lava would be expected to build a high mountain, whereas the fall of dust could form a shallow crater of large diameter.

Supplies of Follicle-stimulating Hormone

THE Endocrinology Study Section, U.S. National Institutes of Health, announces that it is prepared to distribute, free of charge to qualified investigators, limited amounts of purified sheep pituitary follicle-stimulating hormone. The preparation has been packaged in two forms: (1) vials containing 5 mgm. for use only as a standard in assay procedures; (2) vials containing 25 mgm., for experimental use. The preparation is a sterile, lyophilized powder, free or nearly free of other hormonal activities. Detailed specifications will be distributed with each sample. Application for supplies should be made to the executive secretary, Dr. R. T. Hill, Endocrinology Study Section, National Institutes of Health, Bethesda 14, Maryland, with a brief outline of the intended work and an estimate of the amount needed. Allocations will be made after consideration of the merits of the intended work.

The Night Sky in April

NEW moon occurs on April 8d. 03h. 29m. U.T. and full moon on April 23d. 05h. 13m. The following conjunctions with the Moon take place: April 11d. 06h., Venus 5° N.; April 14d. 11h., Mars 7° N.; April 25d. 00h., Jupiter 3° S.; April 27d. 14h., Saturn 4° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Aldebaran on April 23d. 14h., Venus being 7·2° N. There will be an annular eclipse of the Sun on April 8, invisible at Greenwich. The path of annularity crosses Australia. Mercury is unfavourably placed for observation. Venus is an evening star, visible in the south-west after sunset. Conditions are very favourable for observation. Venus sets at 21h. 35m., 22h. 20m. and 23h. 00m. on April 1, 15 and 30, respectively; its stellar magnitude is − 3·5. Its distance decreases during the month from 122 to 104 million miles and the visible portion of the visible disk decreases from 0·828 to 0·734. Mars is moving eastwards among the stars and passes from Taurus into Gemini during April. It sets at 1h 25m., 1h. 05m. and 0h. 40m. at the beginning, middle and end of the month, respectively. Its stellar magnitude decreases from + 1·3 to + 1·6, its distance from the Earth increasing from 148 to 173 million miles. Jupiter rises at 23h. 10m., 22h. 10m. and 21h. 00m. on April 1, 15 and 30, respectively; it is near β Scorpii. The stellar magnitude of Jupiter is − 2·0; its distance on April 15 is approximately 420 million miles. Saturn is a morning star in Sagittarius, rising at 2h. 00m., 1h. 05m. and 0h. 00m. at the beginning, middle and end of the month, respectively. Its stellar magnitude is + 0·7; its distance from the Earth on April 15 is approximately 910 million miles. There are no occultations of stars brighter than magnitude 6 observable from Greenwich. The Lyrid meteors are active during April 20–22, but conditions are unfavourable.

Announcements

THE 1958 James Clayton Prize of the Institution of Mechanical Engineers has been awarded jointly to William Munger Heynes (director and chief engineer, Jaguar Cars, Ltd., Coventry) for his outstanding contribution to the design and development of the modern automobile, and to Sir F. Ewart Smith (deputy chairman, Imperial Chemical Industries, Ltd.) for his personal contribution to the advancement of mechanical engineering, particularly in the chemical industry, and to the training of engineers. This prize is awarded annually to a member or members of the Institution who, in the opinion of the Council, contribute most in the year to modern engineering science by research, invention, experimental work or a treatise or paper on a modern engineering subject, or originality in engineering design or by service to engineering.

HARRY POLACHEK, technical director of the Applied Mathematics Laboratory of the David Taylor Model Basin, has recently been appointed chairman of the editorial committee for the quarterly journal *Mathematical Tables and Other Aids to Computation*, published by the Division of Mathematics of the U.S. National Academy of Sciences—National Research Council. He succeeds C. B. Tompkins of the University of California at Los Angeles, who has held the post since November 1954. Articles for publication in the journal should in future be addressed to Harry Polachek, editor, *Mathematical Tables and Other Aids to Computation*, David Taylor Model Basin, Washington 7, D.C.

A SYMPOSIUM on "Oxidation" is to be held in Queen Mary College, London, on April 13 and 14. It is intended to provide an opportunity for discussing the present state of knowledge of the oxidation of organic compounds in the liquid phase and in particular by chromic acid and permanganate. Inquiries can be addressed to Dr. W. J. Hickinbottom, Department of Chemistry, Queen Mary College, London, E.1.

THE tenth Conference of the British Occupational Hygiene Society will be held in Stephenson Hall, University of Sheffield, Oakholme Road, Sheffield, 10, during April 14–15. The Conference, which will be devoted to a discussion of the control of dust and fumes in industry, is to be opened by H.M. Chief Inspector of Factories. Papers will be presented by speakers with experience of the subject in the cotton and asbestos industries, in iron foundries, in welding and electro-plating. Non-members are eligible to attend this conference on payment of a registration fee. Further details can be obtained from the honorary scientific secretary, Dr. D. Turner, The Associated Ethyl Company, Ltd., Ellesmere Port, Cheshire.

THE third meeting of the Welsh Soils Discussion Group will be held on April 19 at the National Agricultural Advisory Service Centre at Trawscoed, near Aberystwyth, when Dr. Rice Williams will open a discussion on "The Soils of the Aberystwyth Area" and arrange for local field inspection of selected soil series. This meeting will occupy most of the day, and arrangements will be made for lunch at Trawscoed. Members of the Group, and others interested, can obtain further information from the secretary of the Group, Mr. J. A. Taylor, Department of Geography, University College of Wales, Aberystwyth.

PROBLEMS OF COLLECTIVE MOTION IN PHYSICS

A CONFERENCE on various aspects of collective behaviour in physics, sponsored by the Physical Society, was held in the Department of Physics in the University of Birmingham during January 2–3; the visitors were received by the vice-chancellor, Dr. R. S. Aitken. It was hoped that the main talks would be suitable as an introduction to the subject for theoretical physicists not familiar with the theory of collective motion and also for experimental physicists. It must be said, however, that apart from the talks on the electron theory of metals and on liquid helium, the talks were clearly addressed to physicists actively working on the subject under discussion: this was even more the case with the discussions.

The first session was devoted to gaseous plasmas. W. B. Thompson (Atomic Energy Research Establishment, Harwell) described a method for deriving the hydromagnetic equations by taking suitably chosen moments of the Boltzmann equation in cases in which collisions may be neglected. This procedure is the counterpart to the Hilbert–Chapman–Enskog method of deriving the equations of ordinary hydrodynamics. S. F. Edwards (Manchester) discussed methods of describing the dynamics of a plasma in thermal equilibrium, including a derivation of the Debye–Hückel screened potential, of the equation of state, and of the plasma oscillation frequency. He also discussed briefly a variational method for deriving the electrical conductivity of a plasma. In the discussion following these two papers it was pointed out that although the equations used by Thompson will break down, thus indicating the possible occurrence of shock-waves, they cannot be used to describe such shock waves as they are essentially an adiabatic approximation. R. Balescu (Brussels) reported briefly on work in Prigogine's group on obtaining by iteration methods asymptotic solutions of the Liouville equation valid for long times and large distances.

The second session dealt with plasma problems in the electron theory of metals. S. Raimes (Imperial College of Science and Technology, London) gave a lucid account of the Bohm–Pines theory of plasma oscillations in metals and of their introduction of a cut-off wave-number k_c above which no collective degrees of freedom will occur. He discussed the shortcomings of Pines's original variational method for determining k_c. Dr. Raimes then showed how this theory can account for the observed density of states curve for such metals as sodium, pointing out the importance, shown by Fletcher and Larson, of second-order effects. In the discussion, Prof. H. Fröhlich (Liverpool) pointed out that k_c should be determined by using a trial wave function in conjunction with the correct Hamiltonian, and not with an approximate Hamiltonian as was done by Pines. S. F. Edwards (Manchester) and R. Leigh (Atomic Energy Research Establishment, Harwell) reported on work in progress along those lines. Edwards is using wave-functions including two-body correlations, whereas Leigh uses wave-functions of the de Shalit–Weisskopf type. In this connexion Fröhlich suggested the consideration of a one-dimensional plasma for investigating the accuracy of the results obtained. D. Bohm (Bristol) discussed the difficulties connected with degrees of freedom with wave-numbers of the order of magnitude of the Debye wave-number. In that connexion, C. G. Kuper (St. Andrews) reported work on a charged boson gas, where a Bogoliubov-type transformation can be used leading to a smooth transition from particle to collective degrees of freedom.

The third session covered liquid helium and superconductivity. The talk by G. V. Chester (Birmingham) was probably for most people one of the most interesting aspects of the conference. In it he discussed the four main kinds of collective motion which occur in liquid helium below 1·6° K. These are the superfluid hydrodynamic potential flow, phonons, rotons and the Onsager–Feynman vortices. Feynman and Cohen's determination of the excitation spectrum was dealt with, and also the experimental work of Hall and Vinen which shows the existence of vortex lines and probably their quantization. In the discussion following this paper, Prof. H. Fröhlich (Liverpool) and Prof. R. E. Peierls (Birmingham) voiced objections to the Feynman–Cohen calculations, while Kuper directed attention to the influence of self-energy corrections. Both O. Penrose (Imperial College of Science and Technology, London) and Kuper asked how far the concept of independent collective excitations was valid. In reply, Chester said that the inelastic neutron scattering data, on helium II, strongly suggest that the concept is valid up to about 1·7° K.

J. G. Valatin (Birmingham) gave an account of the Bardeen–Cooper–Schrieffer theory of superconductivity, mentioning in passing the work of Martin and Schwinger, Gorkov and Galitskii, who are using a Green function approach. He also briefly discussed how the recent theories can account for the electromagnetic properties of superconductors. A lively discussion followed in which Prof. Fröhlich warned against non-gauge invariant theories, because spurious Meissner effects are only too easily obtained. He also pointed out that in the present form of the theory the total momentum fluctuates in the superflow. These fluctuations and those in the number of quasi-particles make it difficult to prove that a superconductor in the present theory has, indeed, zero resistance, as was pointed out by Kuper, who also asked when an energy-gap leads to a superconductor and when to an insulator. Prof. Peierls defined a superconductor as a substance in which a current-carrying state with an energy close to the ground-state level is possible, and in which no transitions are possible from such a state to states with lower current densities, not even through intermediate states, as happens in normal metals. Prof. Peierls also pointed out the difficulty of estimating the errors involved in the present theory and suggested an approach similar to Feynman's approach to liquid helium, since in that case a variational method could be used to estimate the energy gap.

B. Bayman (Copenhagen) discussed the Bohr–Mottelson explanation of the 'energy-gaps' found in nuclei. Empirically, it is found that the first excitations of a single-particle nature—as distinct from a collective one—in the region of large deformation are much higher in energy than one would predict from the Nilsson model, in which the particles are assumed to move independently in a distorted well. This can be explained by a correlation between pairs of particles of opposite magnetic quantum number, in an unfilled shell. This pairing in angular momentum is similar to the pairing in linear momentum in the Bardeen, Cooper and Schrieffer model. Bayman discussed calculations of Beliaev, who incorporated the pairing simply by making a transformation to a quasi-particle representation. In the region near closed shells, the pairing correlation leads to so-called vibrational states. Their energy spectrum is essentially that produced by Racah's pairing force, so that many of the results of the seniority scheme can be used. In the discussion J. P. Elliott (Southampton) reported on the status of his generalized shell-model approach, and Prof. Peierls discussed briefly the variational scheme for obtaining rotational levels.

The conference was considered by all present to have been a great success, and I for one hope that another conference on the same subject can be arranged in a few years time to review the progress made in the intervening period. D. ter Haar

INDUSTRIAL HEALTH IN BRITAIN

THE annual report of the Chief Inspector of Factories on Industrial Health for the year 1957* is the first report on industrial health to be published separately and is, to some extent, experimental. Its first chapter, reviewing the year, deals with general questions, including references to new and developing problems and to progress made in solving old problems. The second chapter deals with cases of industrial disease, poisoning and gassing which occurred during the year, and the third chapter deals more extensively with industrial dermatitis. Points which were raised on the statutory draft Compressed Air Special Regulations were all resolved by the end of the year, and the Regulations came into operation on April 21, 1958. The report of the pilot industrial health survey of Halifax was studied in detail by a sub-committee of the Industrial Health Advisory Committee, and afterwards an abridged version of the report was published and arrangements were made for the survey team to approach occupiers of factories in Halifax employing more than 250 workers with the view of interesting them in the advantages of the provision or extension of medical and nursing services.

A committee of inquiry into precautions against anthrax was set up in February 1957, and there was evidence during the year that factory occupiers pay insufficient attention to making adequate provision for first-aid treatment, as required under the Factories Act. In the light of discussions between representatives of Government departments which have responsibilities for first aid, including representatives of the Medical Research Council, the contents of first-aid boxes in factories, as prescribed by the First Aid in Factories Order, 1938, and the leaflet giving advice on first aid treatment have been reviewed, while measures to stimulate recruitment and training of first-aid personnel were also discussed. The third interim report of the Joint Advisory Committee of the Cotton Industry on "Dust in Card Rooms" has been brought to the notice of all firms concerned, and it has been made clear to occupiers that, since a satisfactory system of removing dust in card rooms is now available, it is expected that early action will be taken. Plans were made for extending the Inspectorate's facilities for collecting and analysing dust by formation of a second dust-counting team.

The chapter on industrial dermatitis summarizes known facts on the cause and particularly the prevention of this disease which have already been made known in departmental and other publications. Predisposing factors are also indicated, and stress is laid on the importance of taking appropriate measures before and not after trouble has occurred. These include replacement of the harmful agent by one that is non-irritant or less harmful ; selection of personnel ; reduction of contact to a minimum, or complete elimination of contact ; regular and frequent inspection by trained observers ; and cleansing of the skin.

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* Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories on Industrial Health for the year 1957. Pp. 50. (Cmnd. 558.) (London: H.M. Stationery Office, 1958.) 3s. net.

INTERNATIONAL STANDARDS FOR DRINKING-WATER

THERE is at present a wide diversity in water treatment and quality in different countries, and the need for some sort of international agreement on what constitutes a safe supply of drinking-water has long been apparent. The question was raised at the Congress of the International Water Supply Association in Amsterdam in 1949 and again in Paris in 1952, but the prospect of accord in the near future seemed remote. In 1953 the matter was taken up by the World Health Organization, and a questionnaire was circulated to member States. The replies served to reiterate the differences in attitude, and in view of the increase in international travel, particularly by air, to emphasize the desirability of agreed standards.

Regional study groups of experts were convened to study the problem in the European, Eastern Mediterranean, and South-east Asia and Western Pacific regions. The reports of these various groups were used as a basis for discussion by a further group meeting in Geneva in 1956 and the standards now proposed were put forward by this body. It is not suggested that these standards represent perfection ; on the contrary, as the preface specifically points out, they are tentative and subject to modification after experience of their application. In some cases the standard proposed is not as high as that habitually achieved by some undertakings, but the sources of water supply used for public consumption are so different in their chemical and bacteriological content and treatment methods so limited by technical and financial resources that it is not to be expected that the high standard reached in certain localities will immediately become universally applicable. The standards suggested represent rather the minimum requirements to which a public water supply should conform and in the absence of which it cannot be considered entirely free from risk. This is in itself a great advance and will be of inestimable value to health and water authorities in those parts of the world where at present water supplies do not attain the desired criteria.

In the International Standards for Drinking Water*, recently published by the World Health Organization, a chapter is devoted to each of the subjects of bacteriological, chemical and physical, biological and radiological requirements. This is followed by a section in which are indicated matters requiring further research in each of these fields. In some cases it might appear that the subject suggested for study has already been adequately investigated, but it can do no harm for some old ground to be re-covered if the results are made more widely known and a re-assessment of some cherished beliefs may prove salutary.

In a rapidly expanding subject it is inevitable that a publication of this kind should be somewhat behind the latest information. This applies particularly to the chapter on radiological requirements, which seems unduly brief. There is no mention of the part played by the naturally occurring isotope, potassium-40, in contributing towards the total radioactivity in water, although it is only fair to say that for further information the reader is referred to the recommendations of the International Commission on Radiological Protection.

Any consideration of standards, particularly in the bacteriological or chemical spheres, must take some account of the methods whereby these are measured, and the second, and larger, portion of the book is devoted to a series of approved methods for bacteriological, chemical and biological examination of water. Starting with a list of required materials, each procedure is explained step by step in simple language which is a model of clarity. Not the least important sections are those detailing the particulars to be supplied with samples and the recommendations on the frequency of sampling. Tables are given for the computation of the most probable number index with upper and lower confidence levels. In the chemical section, lists with permissible levels are provided not only of those naturally occurring substances which may affect potability but also of toxic materials such as lead, arsenic, selenium, chromium and cyanide, with details of methods for their estimation.

If one may venture a further minor criticism of so valuable a work, it is that a comprehensive index might have increased its usefulness. As it is, the volume is an excellent example of what can be achieved by international co-operation and a milestone on the way to safe water supplies throughout the world.

E. WINDLE TAYLOR

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* World Health Organization. International Standards for Drinking Water. Pp. 152. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) 12 Swiss francs; 20s.; 4 dollars.

THE WEIZMANN INSTITUTE OF SCIENCE

THE report for 1956–57 of the Weizmann Institute of Science*, besides summarizing the scientific activities of the several departments and sections, includes a list of publications during the period and details of the scientific staff, as well as of the administrative and technical staff and supporting committees. It is introduced by a statement of policy for the future of the Institute by Mr. M. W. Weisgal, chairman of the Executive Council, which expresses grave concern regarding the financial position of the Institute. Anticipated income for the four years April 1956–March 1960 fell short of estimated requirements by about 6 million dollars, and the measures proposed by Mr. Weisgal include launching a campaign for an Endowment Fund of 25 million dollars.

Fundamental research in the Department of Applied Mathematics was directed mainly to the solution of mathematical problems in statistical mechanics, wave propagation, geophysics, hydrodynamics and X-ray crystallography. In nuclear physics, besides investigation on nuclear models, some work on reactor physics was undertaken for the Israel Atomic Energy Commission. The Department of Isotope Research records progress in the production of stable isotopes, the use of stable and radioactive isotopes in studying the mechanism of inorganic and organic reactions and in various applications of natural and artificial radioactivity. Investigations by the Department of Organic Chemistry embraced the structure of natural compounds, the chemistry of the sphingolipids, steroid and acetylene chemistry, syntheses in the terpene series, petroleum chemistry and applied spectroscopy.

Besides studies of polyelectrolytes, including their biological aspects, in the Department of Polymer Research, gels, membranes and mechano-chemistry received attention, as well as polynitroethylene, polyvinyl bromide and polyvinylanthracene. The Department of X-ray Crystallography continued to investigate intra- and inter-molecular compression forces on molecular structure and to study the mechanism of solid-state reactions by combined X-ray crystallographic and physico-chemical methods, while work in the Department of Experimental Biology included such diverse fields as the biological mechanism of the induction of tumours, the metabolism of urethane in relation to its tumour-inducing activity, the mechanism of deciduoma formation and its relation to placental implantation of the ovum, immuno-genetics of tumour implantation, radiobiological aspects of tumour immunity, biochemical and endocrinological aspects of sugar metabolism and problems in human genetics and neuropharmacology. The Department of Biophysics continued to be concerned mainly with work on synthetic poly-α-amino-acids and their use in elucidating chemical and physical properties of proteins and natural polypeptides. In the Department of Electronics a more generalized theory of rotational magnetic processes was formulated and several magnetic measuring devices were built. The main effort of the Infra-red Section was on the construction of a large vacuum spectrometer-refractometer for use in the near infrared region; the Section of Photochemistry and Spectroscopy investigated chemical processes involved in photochromic phenomena and the influence of ionizing radiation and high-energy particles on phototropic and photochromic compounds; and the Section of Plant Genetics was concerned with the mechanism of the development of sex in plants.

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* Weizmann Institute of Science. Report 1956–1957. Pp. 190. (Rehovoth: Weizmann Institute of Science, 1958.)

THE BRITISH FLORA DURING 1958

THE publication during 1958 of a new and authoritative list of vascular plants accepted as established members of the British flora[1], and including some 2,895 species and 538 hybrids, is a timely reminder of the relative thoroughness with which the flora has been investigated. The additions which continue to be made annually are evidence that native plants can be long overlooked even on the best-worked ground, and that new aliens continue to find ecological niches where they can establish themselves in competition with species already present. Comparison of the new list with the last full-scale list of the British flora issued in 1928 shows that since then there has been a net addition of some 370 established species. That botanists can add an average of 12 such species annually (and this takes no account of casuals) shows how rapidly the known British flora is changing.

At the annual exhibition meeting of the Botanical Society of the British Isles, held in the lecture hall of the Royal Horticultural Society on November 29, the exhibits included several interesting additions to the British list. One of these was *Juncus subulatus* from the salt-marsh at Berrow, Somerset, which was shown by E. W. Davies and J. Willis (Bristol). This salt-marsh was formed about 1910, and its development has been under observation since 1921 and has been the subject of several ecological studies[2–5]. Two large and flourishing colonies of the rush are spreading vegetatively by vigorous growth of the rhizomes in the zone of *Scirpus maritimus*—the latter appeared about 1926 and increased extremely rapidly during the next two years[3]. *Juncus subulatus* is widespread in the salt-marshes of the Mediterranean coast, and Berrow is apparently its most northerly station. Here it is reproducing from seed as well as vegetatively. Now that attention has been directed to the plant, it may well be found elsewhere on the coast of Britain—it can easily be passed over as *J. maritimus* or perhaps as a luxuriant *J. gerardi*.

Another rush added to the British list was shown by N. D. Simpson and S. M. Walters (Cambridge). This is *J. bufonius* subsp. *foliosus*, also a native of the Mediterranean countries, which was found in two places in west Cork and one in south Kerry. In the field it is strikingly different from the usual *J. bufonius*, having flowers often more than 1 cm. in diameter with a dark stripe bordering the greenish midrib of the perianth segments and wider leaves which are not setaceous. The seeds also differ, but the Irish material was not sufficiently ripe to check this character.

An undescribed *Sorbus* from the Avon Gorge was shown by E. F. Warburg (Oxford). This has previously been confused with *S. hungarica*. Dr. Warburg also exhibited two forms of *Sorbus pseudofennica* from Arran which are probably distinct apomictic clones. Two well-established aliens were exhibited by H. J. M. Bowen (Harwell). *Geranium pilosum*, a native of New Zealand, was found in Alderney, and *Hydrocotyle moschata*, also from New Zealand, is freely naturalized in Valencia Island, Kerry.

Several very rare plants were found in new localities during the year. One of the most interesting of these is *Lythrum hyssopifolia*, which was found in quantity at Whittlesford, Cambridgeshire, by Mrs. G. Crompton, and which was the subject of an exhibit by D. E. Coombe, F. H. Perring and S. M. Walters (Cambridge). This is at present known to occur regularly only in Jersey, and it has been found in only four other localities in the present century; but revision of the records shows that there has also been some confusion with an allied species sometimes found as a casual. *Lythrum hyssopifolia* is native in central and eastern England, growing in wet open communities. It seems likely that seed may remain viable for long periods and enable the plant to re-appear in favourable seasons. Evidently the persistent wet conditions of 1958 suited it well.

The discovery of another new locality for an orchid, *Spiranthes romanzoffiana*, is also of special interest. This was found by Lough Corrib in Galway by a party collecting records for the Society's Maps Scheme, and a photograph was exhibited by Miss A. K. Harding and Mrs. B. H. S. Russell. The new locality represents a considerable extension of range from those previously recorded in the south and north of Ireland—it seems that this orchid is spreading into new and widely scattered habitats (including western Scotland and Devonshire). The first authentic inland record of *Equisetum variegatum* from the south of England was the subject of an exhibit by E. F. Warburg (Oxford). This horsetail was found by E. G. Arthurs in an old quarry at Cothill, Berkshire; the nearest previously known station is at Weston-super-Mare.

An important new hybrid was shown by P. M. Benoit. This was between *Euphorbia paralias* and *E. portlandica*, with morphological characters convincingly intermediate between the two parents and fruits failing to complete their development. He found it in two places on the coast of Merionethshire. P. M. Benoit also exhibited an interesting series of synthesized hybrids of *Stellaria*. These included *S. media* × *neglecta* (90 per cent), *S. pallida* × *neglecta* (50 per cent), *S. neglecta* × *pallida* (50 per cent) and *S. pallida* × *media* (23 per cent). The percentages indicate the approximate proportions of sterile pollen grains. The following back-crosses were also shown: *S.* (*pallida* × *neglecta*) × *neglecta*, *S. pallida* × (*pallida* × *neglecta*), *S.* (*pallida* × *media*) × *media*. J. A. Ratter (Liverpool) exhibited hybrids of *Spergularia*, and J. P. Savidge (Liverpool) showed specimens of the only naturally occurring hybrid population of *Callitriche* found during his investigation of the genus. This was from Hillerød, Denmark; the pollen was completely abortive, no female flowers could be found, and the likely parentage was *C. platycarpa* × *C. polymorpha* (the hybrid is a triploid with 15 chromosomes).

Several exhibits demonstrated new work using modern techniques on critical groups. C. D. K. Cook (Cambridge) showed specimens of *Ranunculus tripartitus* from the Lizard and *R. lutarius* from the New Forest, and clones which he had grown from these. These clones are virtually impossible to distinguish in summer; but differences can be detected when they are in their winter state. All attempts at inducing capillary leaves in plants which lacked them have proved unsuccessful. M. C. F. Proctor (Exeter) exhibited a careful study of the characters and habitat variations of *Ulex minor* and *U. gallii*, with maps showing their distribution in Britain and abroad. The two species have been much confused, but appear to be distinct. E. W. Davies (Bristol) is working on *Asparagus*. *A. officinalis* subsp. *officinalis*, the cultivated form, is diploid, while the wild plant from the Lizard, subsp. *prostratus*, is tetraploid ($2n = 40$). A study of the latter on the Lizard peninsula showed that at three localities female plants were at least three times as abundant as male and were morphologically distinct. B. T. Styles (Oxford) demonstrated progress made in work on the species problem in *Polygonum* Section *Avicularia*. Trampling and the situation of the habitat have a considerable influence on the different forms the plants take, but those to which the names *P. aequale* ($2n = 40$), *P. aviculare* s.str. ($2n = 60$) and *P. rurivagum* ($2n = 60$) are at present applied appear to be morphologically distinct. Other exhibits concerned with variation included: pink-flowered *Calystegia*, R. K. Brummitt (Liverpool); *Juncus articulatus*, J. R. Cullen (Liverpool); *Mentha* × *dumetorum*, R. M. Harley (Oxford); *Valeriana officinalis*, C. L. A. Leakey (Cambridge); and *Melampyrum pratense*, A. J. E. Smith. T. D. V. Swinscow showed a living plant which was a descendant, through an unknown number of generations, of the variety of *Dryopteris dilatata* described by T. Moore in 1859 as var. *lepidota*. The plant is a tetraploid ($n = 82$) as is usual with the species in Britain, but morphologically it is perfectly distinct. Moore regarded it as of native origin, but evidence of this is obscure.

Much of the effort of British botanists in the field during 1958 was devoted to collecting records for the Distribution Maps Scheme. This was the final season for data to be incorporated in the atlas, and a map was exhibited to show the distribution by squares of the records received. This showed that there are now no major gaps—in the whole of the British Isles only about thirty of the approximately 3,500 10-kilometre squares of the extended National Grid remain unvisited; ten of these are in Ireland and the remainder mainly in the Outer Hebrides and outlying islands of the Orkneys. In England the average number of records per square is about 400, in Wales 300, in Scotland nearly 200, and in Ireland about 150. The total number of records should exceed 1¼ million. A specimen volume with sample maps and overlays was exhibited to indicate the form the published atlas will take. This may not be available for another two years, but in the meanwhile work will continue on special problems, for which members will be invited to contribute data.

An exhibit of some interesting plants from the British herbarium of the British Museum (Natural History) included a series of *Bromus* with several species not well understood by workers in Britain. From the herbarium of the Royal Botanic Gardens, Kew, there were specimens of species believed to be now extinct in Britain. This exhibit was prepared by the late R. A. Graham, who also showed four 'legendary' British orchids (*Serapias neglecta, Calypso bulbosa, Limnodorum abortivum* and *Orchis pallens*) with a review of the records and evidence. E. S. Edees and K. M. Goodway (Keele) directed attention to salt-marsh plants growing in Staffordshire. These were first brought to notice by Robert Plot in 1686, and at least ten species still occur. Salt deep in the Keuper Marl is brought to the surface by springs, and at least seven areas with salt-marsh plants have been found during the present century. Since these populations are more than fifty miles from the coast, and are likely to have been isolated from the coastal populations for several thousand years, they deserve experimental investigation. F. Rose and Miss P. A. Hitch (Bedford College) demonstrated work in progress on the distribution of *Chrysosplenium oppositifolium* and *C. alternifolium* in south-east England, and experimental work with the object of endeavouring to determine what chemical factors, if any, may be responsible.

Exhibits concerned with alien plants were more numerous than usual as these were particularly invited. Wool aliens were shown by Miss C. M. Goodman, J. G. Dony and J. E. Lousley, while Mrs. H. N. Clokie (Oxford) exhibited specimens from the Druce herbarium of interest in connexion with the published work[6] of Miss I. M. Hayward and G. C. Druce on this group of aliens. Miss R. M. Barnes (Norwich Castle Museum) showed specimens and photographs from a Suffolk tannery where sheep skins imported from many countries are processed. Other exhibitors provided aliens of garden origin, or brought in with grain, or of special habitats like refuse heaps—some of the species shown are now well established, and others likely to become so. An example of this was *Erinus alpinus*, which D. P. Young found associated with a native arctic–alpine flora near Bettyhill, Caithness.

There were several displays of excellent colour-slides, including a fine series shown by the National Trust for Scotland of arctic–alpine plants on Ben Lawers. Postage stamps with pictures of plants of interest to botanists were shown by Mrs. A. N. Gibby. The exhibit illustrating the junior meeting at Banyuls in the Pyrenees at Easter 1958 was a reminder of the work the Society undertakes for students.

From the Society's 1958 exhibition it would appear that progress in adding to the knowledge of the British flora was less spectacular than it has been recently. Important additions were less than the average of the past thirty years, and exhibits based on sound research work less numerous. Variations in the interest of exhibits must inevitably arise from year to year, and the fact that 1958 was not a good one is not necessarily an indication that there has been any decline in the activity of British botanists. In view of the great handicap to serious field work imposed by inclement weather throughout the season it is surprising that they have achieved so much.

J. E. LOUSLEY

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LINEAR TRANSFER OF A POTENTIALLY MUTANT STATE IN BACTERIA

By Dr. F. KAUDEWITZ
Max-Planck-Institut für Virusforschung, Tübingen

BY observing the pattern of expression shown by reversions from auxotrophy to prototrophy, induced by ultra-violet light, a new type of mutation delay in bacteria has been found. The strain used was the lysin-deficient lys-1 of *Salmonella typhimurium* isolated by E. Witkin. Until about 50 hr. after induction by ultra-violet irradiation the reversions of lys-1 to prototrophy are extremely sensitive to temperature: incubation below 34° C. gives optimal yields, above 36·5° C. reversions were not found (Fig. 1).

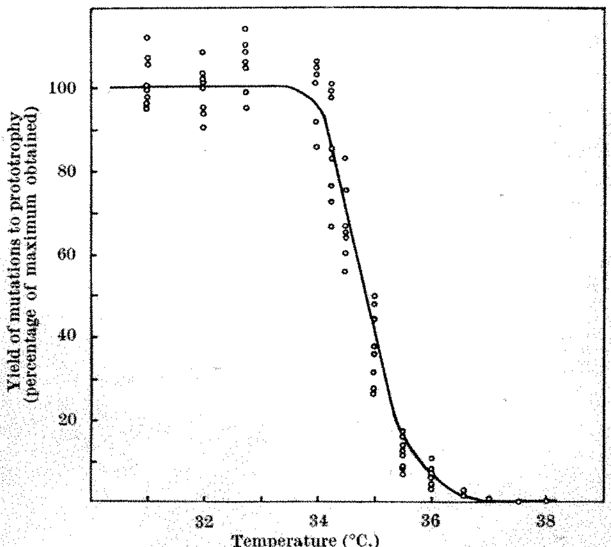

Fig. 1. Yield of mutations induced by ultra-violet light irradiation to prototrophy of strain lys-1 of *Salmonella typhimurium* as a function of incubation temperature

The growth-curve of lys-1 cells irradiated with ultra-violet light so as to yield a survival-rate of 10 per cent and plated on minimal-agar enriched with 0·05 per cent nutrient broth (Fig. 2, curve *a*) shows that cell division begins after a lag-period of about 3 hr. After incubation at 34° C. for 4 days, prototrophic colonies appear each of which represents an independent mutation. Newcombe's technique of re-spreading at intervals after plating[1] provides a method for estimating the number of cells potentially capable of reverting afterwards to stable prototrophs. Fig. 2, curve *b* demonstrates that the increase in such cells starts 5 hr. 40 min. after plating, that is, 2 hr. 40 min. later than the increase of non-mutated cells. From 5 hr. 40 min. to about 7 hr. the curve of increase of these potential reversions (Fig. 2*b*) and the growth-curve of lys-1 cells not induced to prototrophy (Fig. 2*a*) have the same slope.

At about 7 hr., however, there is a sudden break in the curve of increase. Thereafter, this curve is concave even though the results are plotted on a semi-logarithmic scale. The deviation from linearity can be explained by the fact that the reverted clones are inhomogeneous with respect to their growth-characteristics. Re-spreading favours selection of fast-growing types. Thus the later re-spreading is carried out the higher will be the percentage of fast-growing colonies obtained (scheme Fig. 2*c*). Hence, at about 7 hr. the slope of the curve of increase mainly results from the multiplication of slow-growing clones; at about 25 hr. the slope depends almost entirely upon the multiplication of fast-growing colonies.

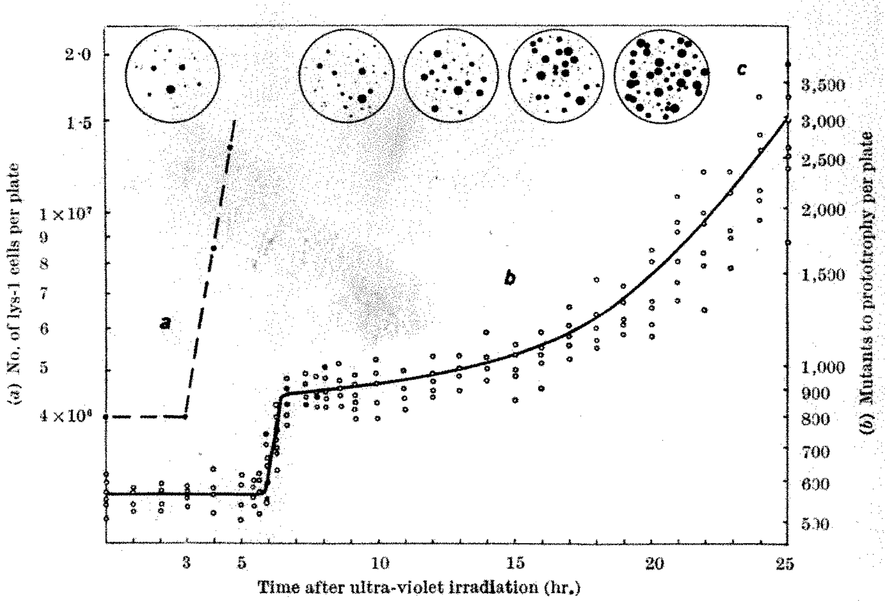

Fig. 2. Relation of potential mutation to prototrophy to time of re-spreading after induction by ultra-violet light. *a*, Growth curve of surviving cells: *b*, number of cells/plate capable of giving rise to prototrophic colonies; *c*, scheme of appearance of plates

The delay in the increase of mutated cells observed after irradiation might be caused by: (1) the temporary formation of filaments which afterwards break up (Fig. 3); (2) a prolonged lag-phase in the mutated cells; (3) the segregation of genetic units, for example, separation of a mutated nucleus from unchanged ones; (4) the linear transfer of the character 'mutated' or 'potentially mutated' to one of two daughter-cells.

The first-mentioned possibility was disproved by the results of experiments in which cell-suspensions obtained by washing plates 5 hr. 10 min. after plating were centrifuged and filtered. No difference was found between the percentage of potential mutants present in the pellet and in the supernatant or present

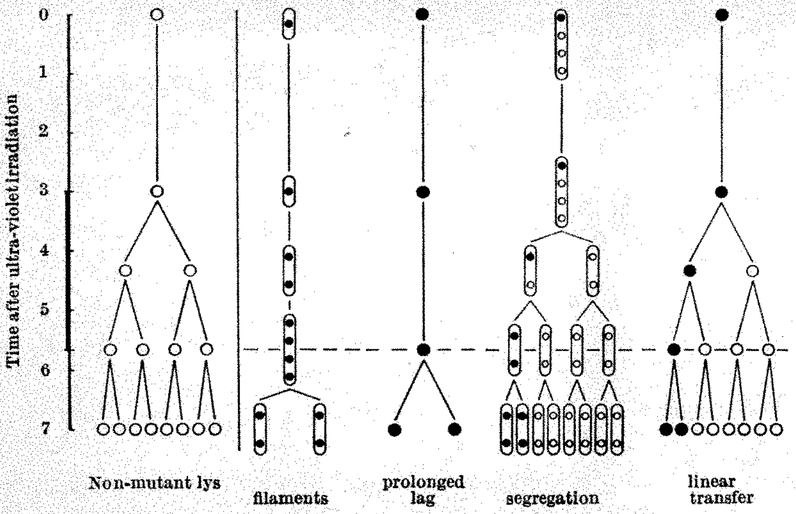

Fig. 3. Mechanisms which might cause a delay in the increase of cells mutated to prototrophy observed from 3 hr. to 5 hr. 40 min. after ultra-violet induction (cf. Fig. 2)

in the filtrate and on the filter. The existence of a prolonged lag-phase after plating, as suggested in hypothesis 2, would imply that membrane synthesis in potentially mutated cells is much less effective than in non-mutated cells. Were this the case the percentage of cells in both categories killed by a given dose of penicillin would be different. Experimental results[2], however, have demonstrated that during the time-interval 3–5 hr. the same percentage of potentially mutated and non-mutated cells were killed by a comparable dose of penicillin. This finding indicates that potentially mutated cells do not have a prolonged lag-phase. The third hypothesis, namely, a segregation of genetic units, would require a minimal number of cell divisions for the expression of the recessive phenotype of a mutant. Therefore, a prolongation of generation-time would result in a postponement in the increase of mutated cells. To test this hypothesis aliquots of cells irradiated by ultra-violet light were placed on enriched or minimal medium (Fig. 4). The growth-curves of non-mutated cells obtained with the two media have different slopes, indicating a different time between cell-divisions. However, on both media, as shown with the re-spreading technique, the increase in the number of mutants starts at exactly the same time, that is, at 5 hr. 40 min. after plating. Thus the segregation hypothesis is disproved.

The hypothesis of linear transfer of character 'reversion' assumes the concurrence of a potentially mutant state which is transferred in a linear order to only one of the offspring of an affected cell. To test this thesis experiments were carried out using the chequerboard technique of Witkin and Thomas[3]. This method yielded clonal offspring of the irradiated cells. Assuming linear transfer it would be expected that at any time before 5 hr. 40 min. each clone derived from a potentially mutated cell would contain only one mutated cell, but many non-mutated cells. At 7 hr. and later, however, there should be in such a clone at least two cells which give rise to prototrophic colonies. This actually was found (Fig. 5). The delay of the increase in number of potentially mutated lys-1 cells after irradiation by ultra-violet light was proved by this finding to be due to linear transfer of the potentiality to express the prototrophic character.

To solve the problem of what kind of material transfers this potentiality, experiments still in progress add the following evidence: while about 10 per cent of reversion strains can serve as donors in transduction of lys-1 to prototrophy, 100 per cent of reversion strains (after infection) give rise to phages which transduce all wild-type markers of strain lys-1. By transduction analysis the transducible reversions were shown to be due to suppressors at loci other than the mutational site of lys-1. In early stages of their origin all lys-1 reversions, transducible or not, show the same degree of temperature sensitivity and linear transferability. From this it may be concluded that all lys-1 reversions have the same basic mechanism of origin. Why, then, are some of them transducible, and others not? The results of experiments in which X-irradiation was applied to transducing phages synthesized in different

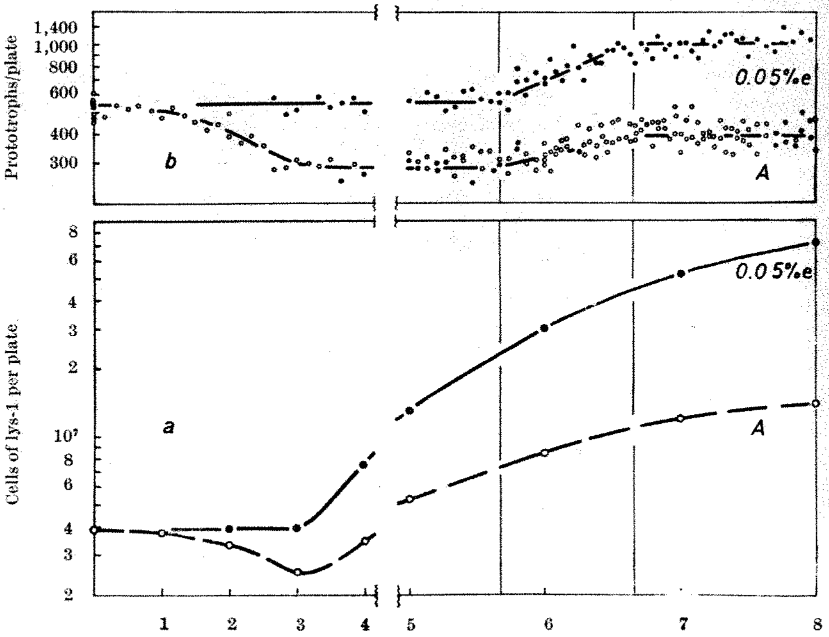

Fig. 4. Lack of dependence of time of increase in potential mutants of prototrophy upon rate of growth of cells surviving after ultra-violet light irradiation. *a*, Growth curves of surviving cells on minimal agar (*A*) and minimal agar enriched with 0·05 per cent broth; *b*, number of cells/plate capable of giving rise to prototrophic colonies on either medium

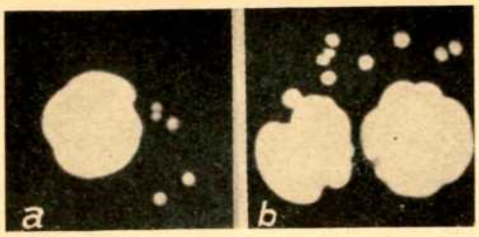

Fig. 5. Results of clonal re-spreading (using the chequer-board technique of Witkin and Thomas) of lys-1 cells potentially mutated to prototrophy. *a*, Re-spreading at 5 hr. 20 min. after ultra-violet induction: the clone was composed of 5 non-mutated microcolony-forming cells and only one cell capable of giving rise to a macrocolony; *b*, re-spreading at 7 hr. after ultra-violet induction: the clone was composed of 9 non-mutated microcolony-forming cells but two cells capable of giving rise to macrocolonies

strains of transducible reversions indicate target sizes which were often larger than one gene-locus. This observation led to the conclusion that the suppressors are non-intragenic changes. They represent translocations of chromosomal segments which in most strains of reversions are too big in size to be incorporated into phage.

The same temperature sensitivity and linear transferability and the rare occurrence of transducibility were shown by reversions arising spontaneously of lys-1 and by reversions of 17 of 134 auxotrophic mutants of *Salmonella typhimurium* and *E. coli*. Thus the phenomena are not unique to strain lys-1.

From the experimental results presented the following working hypothesis is formed. By the mutational event, part of the genetic material may become separated from the chromosome. Without duplication it is transferred by each cell-division for some time in a linear order. Its re-incorporation may lead to a variety of changes in chromosomal architecture which function as non-intragenic suppressors to cause different degrees of prototrophy.

A detailed account of this work will be published in the *Zeitschrift für Vererbungslehre*.

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LIQUID CRYSTALS OF LIPID IN NORMAL AND ATHEROMATOUS TISSUE

By G. T. STEWART

Medical Research Council Laboratories, Carshalton, Surrey

THE chemical composition of the extractable lipids in atherosclerotic lesions is well known, but much less is known about the physico-chemical forms in which the lipids gain access to, and exist in, these lesions in the body. Poole and Florey[1] have shown how sudanophilic fat first appears in the aortic intimal deposits of atheroma in the cholesterol-fed rabbit, and have demonstrated the presence of lipoid-laden macrophages on the endothelial surface. Their observations do not support the idea advanced by Rannie and Duguid[2] that lipid is incorporated into the atheromatous lesion when endothelium overgrows adherent clumps of these macrophages. Sudanophilic fat can be demonstrated in endothelial cytoplasm in areas of intima where no macroscopic deposition of atheroma is visible and where no macrophages are present.

One difficulty which constantly limits work in this field is the fact that microscopy is usually performed upon tissues which have been physically altered, especially with regard to lipid distribution, by fixation, freezing or embedding, and staining. The Oxford workers (Florey *et al.*) have overcome this difficulty so far as circulating cells are concerned by inserting ear-chambers into cholesterol-fed rabbits and have thereby demonstrated that, under experimental conditions, birefringent lipid may be present intracellularly in macrophages[3]. In the studies described below, an attempt is made to examine atherosclerotic and normal tissues and plasma in the fresh state, and at temperatures approaching 37° C. to compare the lipids seen under such conditions with those viewed in conventionally processed tissues. It is thought that the results may have some bearing on the problem of the integration of certain forms of lipid in tissue.

Microscopic Identification of Lipid in Fresh Tissue

When frozen sections of unfixed atheromatous vessels from humans or from cholesterol-fed rabbits are examined by conventional techniques, various forms of lipid besides sudanophilic fat can be detected microscopically including, in unstained frozen sections or films, crystals of fatty acid, free cholesterol and amorphous birefringent material (Fig. 1). A few spheroid objects of diam. 0·5–5μ with a cross or other interference pattern on polarization ('spherulites')

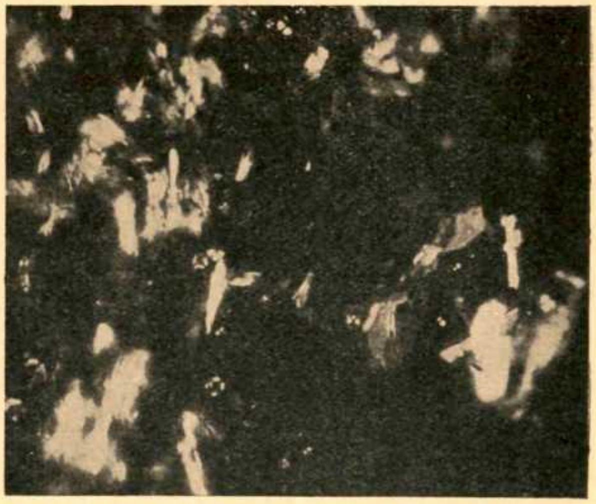

Fig. 1. Film made after freezing from an atheromatous deposit in a cholesterol-fed rabbit. Crystals of fatty acid and free cholesterol, amorphous material and a few spherulites are present (× 400, polarized light)

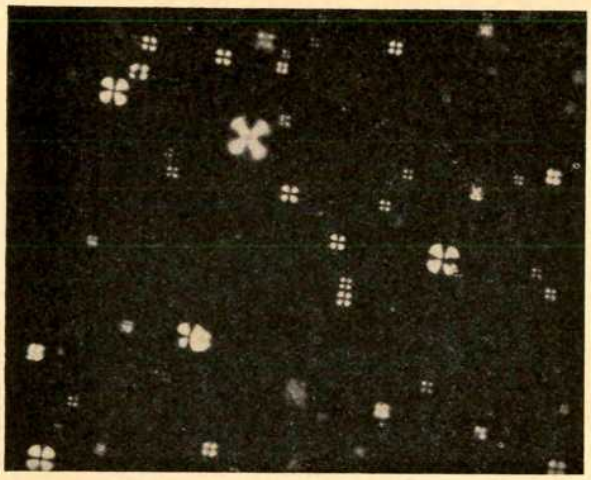

Fig. 2. Film made at 37° C. and photographed at room temperature from an atheromatous deposit in a cholesterol-fed rabbit. The birefringent material consists almost entirely of spherulites (× 400, polarized light)

may also be seen but are never numerous and may be absent in sections viewed soon after freezing.

A very different picture is obtained when fresh preparations are made at 24–37° C. in distilled water or other inert medium from the warm aortic lesions of a cholesterol-fed rabbit which has just been killed. Under such conditions, the intimal deposits are in a semi-liquid state and show, in microscopic films, a predominance of spherulites of diam. 0·5–2·0μ, especially in the superficial layers (Fig. 2). These spherulites, though varying slightly in size, are uniform in shape and interference figure when viewed immediately under polarized white or monochromatic light. Some minute birefringent, ovoid or amorphous particles may also be present; but the true crystals of free cholesterol and fatty acids seen in frozen sections are not visible. On cooling to room temperature, these crystals begin to form slowly, though the spherulites persist. Rapid cooling to 4° C. causes disintegration of many of the spherulites. At −10° to −20° C., this disintegration is practically instantaneous and complete. The spherulites are soluble in fat solvents and show no sudanophilia, though amorphous sudanophilic material is present in films of fresh, warm tissue as in frozen sections. The addition of digitonin (0·5 per cent in 50 per cent alcohol) causes gradual disappearance of the spherulites, with replacement by amorphous and crystalline precipitates.

Spherulites similar to the above are present also in some normal tissues, intra- and extra-cellularly, when scrapings or imprint preparations are made from fresh, wet tissue. They are conspicuous in myelin from the white matter of brain and spinal cord, and may be prominent in the adrenal cortex as well as in the ovaries and secretory endometrium of women of child-bearing age. Spherulites may also be found in testis and semen. In myelin, the optical interference figure of the spherulites may not be greatly altered by freezing or formol-fixation, though in other tissues, spherulites may disappear on freezing and reappear gradually at 24–37° C. Spherulites are not present in normal adipose tissue.

Identification of Lipid Particles in Plasma

Particulate lipid in plasma is usually seen in the form of chylomicrons under dark-ground illumination. These particles, composed largely of triglyceride, are mainly isotropic in plasma examined in the state of normal alimentary lipæmia. In healthy human and rabbit plasma, few, if any, anisotropic particles are present.

In plasma from rabbits fed on cholesterol, anisotropic particles can be found regularly in films made immediately from the meniscus after low-speed centrifugation. These particles comprise spherulites, comparable in size and appearance with those observed in tissue, and minute ovoid or stellate objects, of chylomicron-size, but strongly birefringent. Both types of particle are present extracellularly.

Intravenous injection of sulphated polysaccharides (for example, heparin 100–500 units/kgm.) under conditions already described[4] causes a temporary aggregation of particulate lipid in plasmas, sampled 3–30 min. after injection. Low-speed centrifugation of plasma in this state, carried out at 37° C., causes an opaque pellicle loaded with spherulites and amorphous (isotropic) lipid to separate at the meniscus (Fig. 3). Ultracentrifugation of this plasma at room temperature, adjusted according to the technique of de Lalla and Gofman[5] to a mean density of 1·063 gm./ml. at a mean centrifugal force of 79,420g,

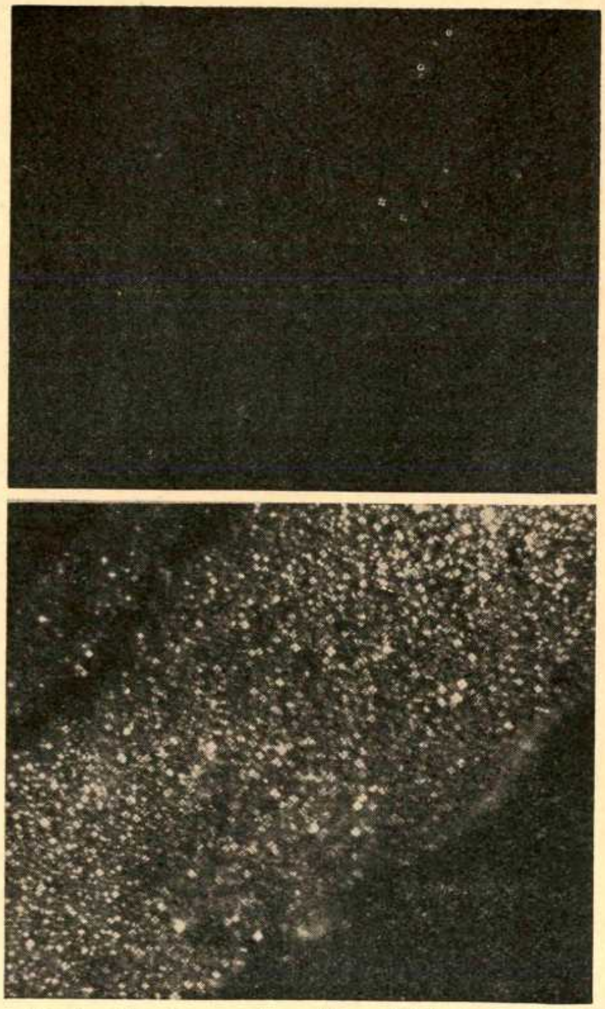

Fig. 3. Films from meniscus of hypercholesterolæmic rabbit plasma after low-speed centrifugation. Above, before injection: a few spherulites are present; below, after heparin 100 units/kgm. intravenously. A pellicle of identically orientated spherulites is present (× 100, polarized light)

causes the spherulites to separate in the low-density layer, in association with lipoproteins of hydrated density 1·00–1·04 gm./ml. This separation occurs within 5 hr. in the ultracentrifuge and serves to indicate the density of spherulites of average size, but does not effect a concentration comparable to low-speed centrifugation at 24–37° C. after the injection of heparin.

Similar spherulites and ovoid particles can sometimes be found, cell-free, in abnormally lipæmic human plasma by the same technique. None has so far been found in normal plasmas of children and adults; but small numbers (of the order of 3–6 in a cover-slip film) have been found in the low-density layer of ultracentrifuged plasmas from three adult males with essential hyperlipæmia and two children with nephrotic hyperlipæmia.

Properties of Spherulites in Tissue and Plasma

In preparations kept at 24–37° C., the spherulites show crystal-like growth, partly as discrete globules, partly as confluent masses. Cooling prevents this growth and provokes true crystallization of fatty acids and steroid rhombs. At 37° C. in glycerol, the larger globules show complex radial and concentric interference figures and a display of polarization colours in convergent white light. The interference figure is altered in accordance with the sign of birefringence when a quarter-wave plate is inserted into the optical system.

When films of plasma or tissue are examined immediately at 37° C., without cooling, the spherulites show a more fluid consistency. The globules are elongated or wavy in outline, and may be larger and confluent (Fig. 4). The interference figure is still discernible, though deformed, within the globule, but no polarization colours are seen. Extinction of the polarized beams leaves the globule with greenish droplet-like refractility in white light.

Possible Significance of these Observations

It is obvious that the spherulites and some of the accompanying ovoid particles here described belong to the liquid phase of tissue, and show crystalline properties while still in a state of 'flow' in plasma and cells at or slightly below body temperature. Such particles possess, therefore, the essential properties of 'liquid crystals', a term first used by Lehmann in 1889[6] to describe the intermediate paracrystalline form of some pure organic substances. Such crystals, now well recognized in various physical systems[7,8], especially where esters, soaps and cholesteric substances are present[9], have received little attention in biology.

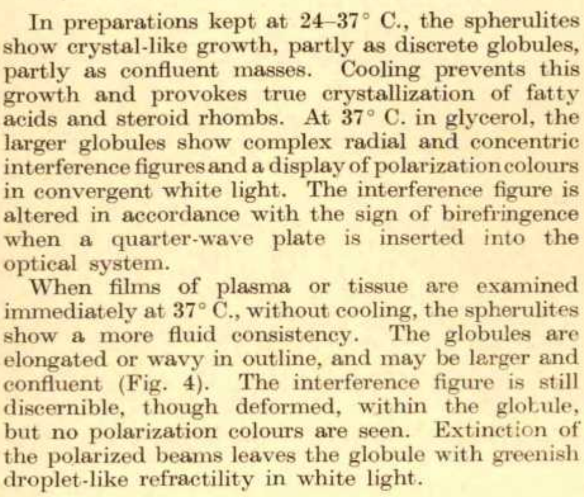

Fig. 4. Film from meniscus of hypercholesterolæmic rabbit plasma after intravenous injection of heparin 100 units/kgm. Whole experiment, including photograph, performed at 37° C. The spherulites are in a state of flow with wavy outlines (× 400, polarized light)

The liquid crystalline form can occur when there are aggregates of systematically orientated molecules of birefringent substance[10]. At a certain temperature, the solid goes into a turbid phase, which is both birefringent and fluid. In this mesomorphic state, the molecules are maintained in stable orientation by specific polar groups and unspecific van der Waals attractions[11]. Alterations in temperature and other physical stresses disrupt the relatively weak intramolecular forces of cohesion, with loss of birefringence, specific interference figures and fluidity.

The liquid crystals here identified in plasma and tissue are stable at, or slightly below, body temperature. Some of their properties—the type of true crystallization on cooling, the development of iridescent polarization colours and complex interference figures on growth—are consistent with the presence of cholesterol esters together with other non-sudanophilic lipids in their structure. It is likely that some of the birefringent material observed in adrenal cortex by Yoffey and Baxter[12] and in circulating macrophages by French[3] is of a similar type. When viewed in fresh tissue, all the birefringent particles are of chylomicron size, or slightly larger, and these presumably represent the natural nuclei from which further paracrystalline growth proceeds in older preparations.

In the plasma colloid, the spherulites and ovoid particles appear to be associated mainly with the macromolecular lipoproteins of lowest density. In some normal tissues—though not to any significant extent in adipose tissue—closely related if not identical particles are present physiologically, while, under pathological conditions, similar particles form a major component of atheromatous substances in the liquid state. The occurrence of the liquid crystalline form indicates that such particles, unlike other forms of physiological and pathological lipid, possess internal cohesive forces which confer stability and may influence their distribution and retention in tissue. The high concentration of spherulites found in the intima of atherosclerotic vessels, together with their association with the low-density lipoproteins of abnormally lipæmic plasmas, suggest that lipid in this form plays a part in initiating and maintaining the atheromatous deposit.

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TRICHLORACETIC ACID-INSOLUBLE PHOSPHATE COMPOUNDS IN CARTILAGE

By R. G. WHITEHEAD and Dr. S. M. WEIDMANN

Biological Research Unit, Dental School and Hospital, University of Leeds

IN a previous communication, we[1] gave the analysis of phosphate compounds in the fraction of cartilage soluble in trichloracetic acid, and found that both adenosine triphosphate and orthophosphate had a high specific activity of incorporated phosphorus-32 when the latter was injected intraperitoneally. The acid-insoluble phosphate compounds have not hitherto been studied in detail.

Dallemagne[2] showed that as a young animal grows older the calcium/phosphorus ratio of ashed cartilage rises until the ratio of tricalcium phosphate is reached. Refuting the theory that the low calcium/phosphorus ratio was due to the primary precipitation of dicalcium phosphate, it was suggested that the phosphate present in excess of that required for a calcium/phosphorus ratio of 1·94 was attached to the organic element afterwards to be hydrolysed when the requisite calcium ions were available for deposition of tricalcium phosphate. In the light of this theory, it was of interest to investigate the matrix-bound phosphate compounds of cartilage.

In preliminary work it was shown that although an upward gradation with age of calcium/phosphorus ratios occurred in the ashed epiphyseal cartilage samples, in the fraction soluble in trichloracetic acid the ratio was always 1·9–2·1, indicating that a compound of the tricalcium phosphate type was always deposited even in the earliest phases of calcification. The phosphate compounds remaining in the acid-insoluble fraction were further analysed by the method described by Heald[3] for similar compounds in brain.

The phospholipid was extracted with chloroform–methanol 2 : 1 (v/v) at 0° C., and the nucleic acids using urea dissolved in a saturated solution of sodium chloride and ammonium sulphate at 100° C. The nucleic acids were afterwards precipitated from this extract as their copper salts. The residue remaining after the extraction of phospholipid and nucleic acid was incubated in 1·0 *N* potassium hydroxide for 18 hr. at 37° C., then 0·2 vol. of 6·0 *N* hydrochloric acid and 0·5 vol. of 10 per cent (w/v) trichloracetic acid were added. The resultant small precipitate together with the remainder of the undissolved organic material were removed by centrifugation. The supernatant was examined for organic and inorganic phosphate by the method of Berenblum and Chain[4]. The inorganic phosphate is produced by the alkaline hydrolysis of phosphoprotein and is of significant importance in brain metabolism. The organically bound phosphate of this fraction is of unknown structure.

The composition of the acid-insoluble phosphate compounds obtained from five litter-mate puppies (3 weeks old) are given in Table 1. It will be observed that no phosphoprotein was detected (in which respect cartilage differs from brain). The concentration of nucleic acid phosphate, the 'unknown organic phosphate' fraction and the acid-insoluble residual phosphate are quite similar to those found by Heald[3] in brain. There is also present a considerable proportion of phospholipid.

Table 1. DISTRIBUTION OF PHOSPHORUS COMPOUNDS IN THE TRICHLORACETIC ACID-INSOLUBLE FRACTION OF EPIPHYSEAL CARTILAGE

The results represent the mean values ± *S.E.M.*

Fraction	No. of animals	Concentration (mgm. P/100 gm. wet wt.)
Phospholipid	5	10·5 ± 0·3
Nucleic acid	5	6·6 ± 0·9
Phosphoprotein	5	None
'Unknown organic phosphate'	5	6·9 ± 0·9
Residue	5	1·53 ± 0·03

In some experiments 330 μc./kgm. of phosphorus-32 was injected intraperitoneally into young kittens and the animals killed 2 hr. later. In Table 2 the specific activity of incorporated phosphorus-32 in the phospholipid, nucleic acid and 'unknown organic phosphate' fraction is compared with the values for adenosine triphosphate. In relation to the adenosine triphosphate the turn-over of these trichloracetic acid-insoluble compounds is very low (Table 2).

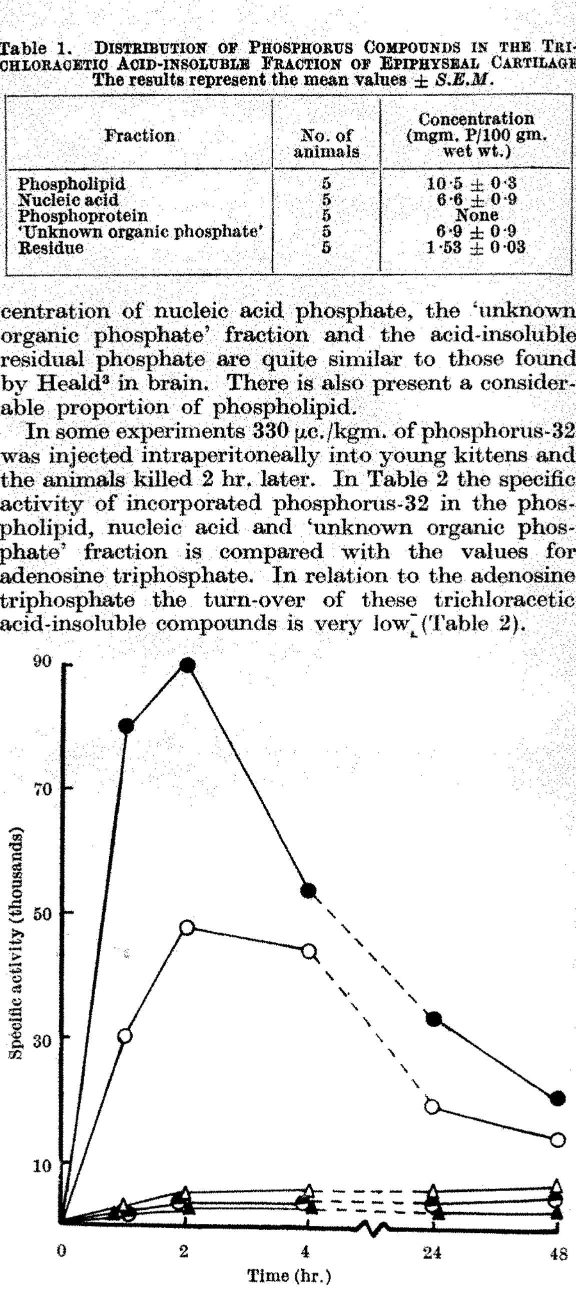

Fig. 1. Specific activity – time relationship for various phosphate compounds in ossifying cartilage, taken from litter-mate puppies, aged 21 days. For definition of specific activity see Whitehead and Weidmann (ref. 6)

●, Orthophosphate; ○, adenosine triphosphate; △, phospholipid; ◓, nucleic acid; ▲, 'unknown organic phosphate' fraction

Table 2. SPECIFIC ACTIVITY OF VARIOUS PHOSPHATE COMPOUNDS IN EPIPHYSEAL CARTILAGE FROM 3-WEEK-OLD KITTENS, MEASURED 2 HR. AFTER THE INJECTION OF PHOSPHORUS-32
Results represent mean values ± *S.E.M.* For definition of specific activity, see Whitehead and Weldmann (ref. 6)

Phosphate compound	No. of animals	Specific activity
Adenosine triphosphate	45	24,800 ± 940
Phospholipid	6	1,000 ± 60
Nucleic acid	6	2,430 ± 280
'Unknown organic phosphate' fraction	6	2,370 ± 160

The results presented strongly suggest the idea that the 'excess' phosphate was temporarily bound to the matrix prior to its deposition as bone salt to be incorrect. It seems probable these phosphate compounds are only part of the normal cell constituents. If part of this phosphate were concerned in a cyclic transfer system from acid-soluble phosphate esters, a close relationship between the magnitude of turn-overs in the two types of compound would be expected; but this is not the case. The latter point was confirmed by a study of the time relationship for the incorporation of phosphorus-32 into the various phosphate compounds. The results (Fig. 1) show the three acid-insoluble compounds exhibit only a slow incorporation of isotope similar to that observed in other tissues, while the adenosine triphosphate has a marked peak at 2–4 hr., and even after 48 hr. has a considerably higher specific activity than the insoluble compounds.

Cartier and Picard[5] suggested that adenosine triphosphate stimulated calcification in cartilage by forming a primary seed, after which bone salt crystallized out automatically on to the seed, and recent work by us[6] has produced evidence in support of this idea. If the seeding effect of adenosine triphosphate is achieved by the phosphorylation of the matrix, as Cartier and Picard[5] have suggested, then the seed should be highly labelled. It would appear that owing to the absence of any highly active component in the acid-insoluble fraction, these compounds do not participate in the seeding mechanism, which one would expect to be a rapid reaction. The considerable loss of tracer after 2–4 hr. in the cartilage orthophosphate of bone salt (Fig. 1) indicates that a fast resorption and redeposition of new bone salt is occurring. It is unlikely that such a rapid reaction could be stimulated by a slowly synthesized phosphate compound.

DiStephano, Neuman and Rouser[7] characterized an acid-insoluble phosphate compound in cartilage which they suggested may play a part in the calcification mechanism. Presumably this compound would be contained in the 'unknown organic phosphate' fraction; but again the absence of any appreciable activity in this fraction indicates the doubtful importance of this ester in calcification.

It would appear that if adenosine triphosphate is essential in the epitactic stimulation of calcification, then this must be achieved either by the formation of a labile acid-soluble seed or as a result of its high energy content. The acid-insoluble phosphate compounds appear to be of little significance in the rapid endochondral calcification of cartilage.

This work has been supported by a grant from the Medical Research Council.

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PREALBUMIN AS A COMPLEX IN THE α-GLOBULIN FRACTION IN HUMAN SERUM

By DR. J. R. TATA*
National Institute for Medical Research, Mill Hill,
London, N.W.7

THE thyroid hormone is normally transported in the blood in association with the 'thyroxine-binding protein', the principal characteristic of which is an electrophoretic mobility on filter paper or in the moving boundary system intermediate between those of α_1- and α_2-globulins[1,2]. This protein fraction can also be concentrated in the fractions of human serum rich in α-globulin submitted to ethanol precipitation or passage through ion-exchange resins[3]. However, experiments with a recently devised non-electrophoretic method for comparing the thyroxine-binding affinities of different proteins[4] showed human serum prealbumin (as isolated by Schultze *et al.*[5]) to have a more intense interaction with thyroxine than other serum proteins. In this connexion it has been shown lately that thyroxine, added to normal human serum, migrated with the prealbumin fraction in starch gel electrophoresis[6], and that a part of the added thyroxine could be made to migrate with the prealbumin fraction even in paper electrophoresis if a fraction rich in prealbumin were added to whole serum[7]. These results have been interpreted by Ingbar[7] to mean that thyroxine-binding protein and prealbumin are two distinct proteins which bind thyroxine, each possessing a high affinity for thyroxine; these are in addition to human serum albumin, which is a secondary binding protein, effective in serum only at higher concentrations of thyroxine. However, the results outlined below indicate that the thyroxine-binding properties of the α-globulin fraction of thyroxine-binding protein are principally due to prealbumin, present as a complex of unknown composition. In this respect, except for the binding of hæmoglobin by haptoglobins[8], little is known about physiologically significant protein–protein interaction in normal serum[9].

As a first approach, the high tryptophan content of human serum prealbumin[5] was used for detecting it in small amounts on paper by development with Ehrlich's[10] *p*-dimethylaminobenzaldehyde reagent. Prealbumin and the Cohn fractions IV-4 and IV-6 rich in α-globulin were the only serum protein fractions to give a positive tryptophan reaction on spot tests on paper (10–25 μgm.), whereas all the other fractions, including α-globulin (Lister), β-globulin (fraction G-2, Lister), β_1-globulin (Protein Foundation, Inc.) and human serum albumin (Lister), failed to react or only reacted very feebly with Ehrlich's reagent. The results of zone electrophoresis on paper (using conventional horizontal electrophoresis at *p*H 8·6[11] and analysis of thyroxine-binding[2]) are shown in Figs. 1 and 2.

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* Beit Memorial Fellow.

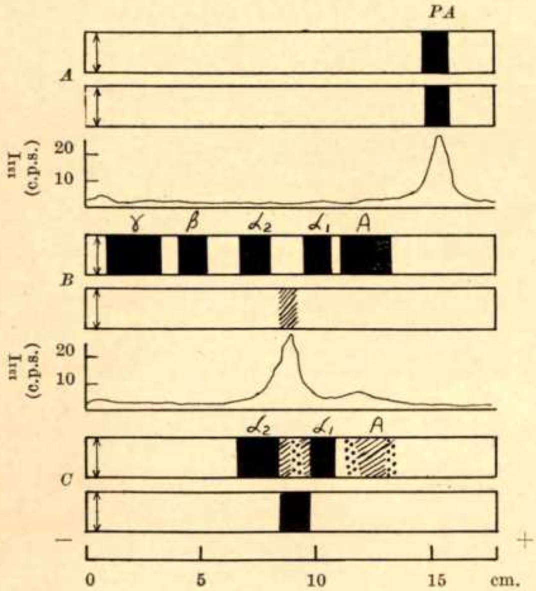

Fig. 1. Paper electrophoretic analysis of (*A*) human serum prealbumin (2·5 mgm./ml.), (*B*) whole human serum, and (*C*) Cohn fraction IV-4 (12·5 mgm./ml.). The upper strip indicates the positions of proteins when stained with bromphenol blue and the lower strip that of the tryptophan-rich protein fraction when stained with *p*-dimethylaminobenzaldehyde for the same sample. Full black areas indicate a strong reaction, hatched lines a moderate one and dotted zones a feeble but positive staining reaction. The curves represent the distribution of radioactivity in electrophoretic pattern if a trace amount of L-thyroxine labelled with iodine-131 was added before electrophoresis. Electrophoresis was performed in 0·075 *M* veronal buffer, *p*H 8·6 at 3·6 V/cm. for 18 hr. Double-headed arrows denote the point of application of samples. *A*, albumin; *PA*, prealbumin

Prealbumin when analysed alone was shown to be a fast-moving protein, using both bromophenol blue and Ehrlich's reagent (Fig. 1*A*), but in electrophoretic patterns of whole serum (Fig. 1*B*) or Cohn fraction IV-4 (Fig. 1*C*) the tryptophan-rich fraction was found in the position occupied by thyroxine-binding protein, namely, between the α_1- and α_2-globulins.

The first indication that human serum prealbumin could form a complex in serum was obtained in experiments in which increasing amounts of prealbumin were added to serum (Fig. 2).

When an amount of prealbumin equal to that used alone (2·5 mgm./ml., Fig. 1*A*) was added to whole human serum (Fig. 2*A*) only a small proportion of it was recovered on electrophoresis as 'free' prealbumin; at the same time, an increase in the material rich in tryptophan in the α-globulin zone was found. Doubling the amount of prealbumin added to the serum (Fig. 2*B*) led to an increased recovery of the original fast-moving component with no concomitant increase in the amount of material rich in tryptophan in the α_1–α_2-globulin zone, suggesting saturation of a possible complex. A qualitatively similar result was obtained when Cohn fraction IV-4 was used instead of whole serum, which further suggested that prealbumin might be associated with an α-globulin component. No such complex formation could be detected with other serum fractions, including human serum albumin (Fig. 2*C*).

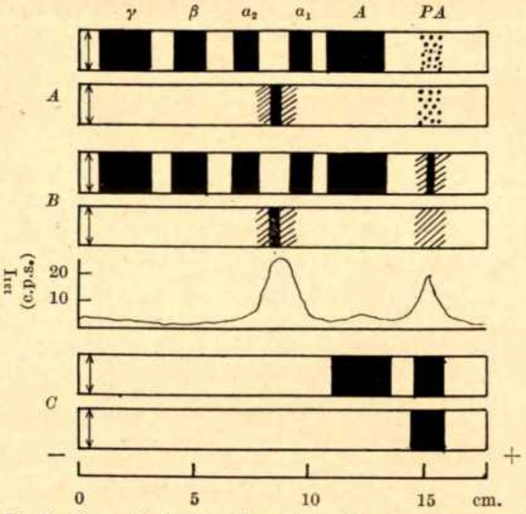

Fig. 2. Paper electrophoretic analysis of human serum to which prealbumin was added to the extent of (*A*) 2·5 mgm./ml., and (*B*) 5·0 mgm./ml. The sample *C* consisted of a mixture of human serum albumin (50 mgm./ml. and prealbumin (5 mgm./ml.). Other details as in Fig. 1

As regards thyroxine-binding, it is noteworthy that when thyroxine labelled with iodine-131 was added to these proteins in trace amounts, it was recovered in the tryptophan-rich zone (Figs. 1 and 2). If more than one zone rich in tryptophan were present (Fig. 2*B*), thyroxine was distributed between the zones in direct proportion to the intensity of the Ehrlich tryptophan reaction. It should be noted that similar distribution of radioactivity was obtained by Ingbar[7] in the paper electrophoretic analysis of thyroxine-binding by serum supplemented with a prealbumin-rich fraction.

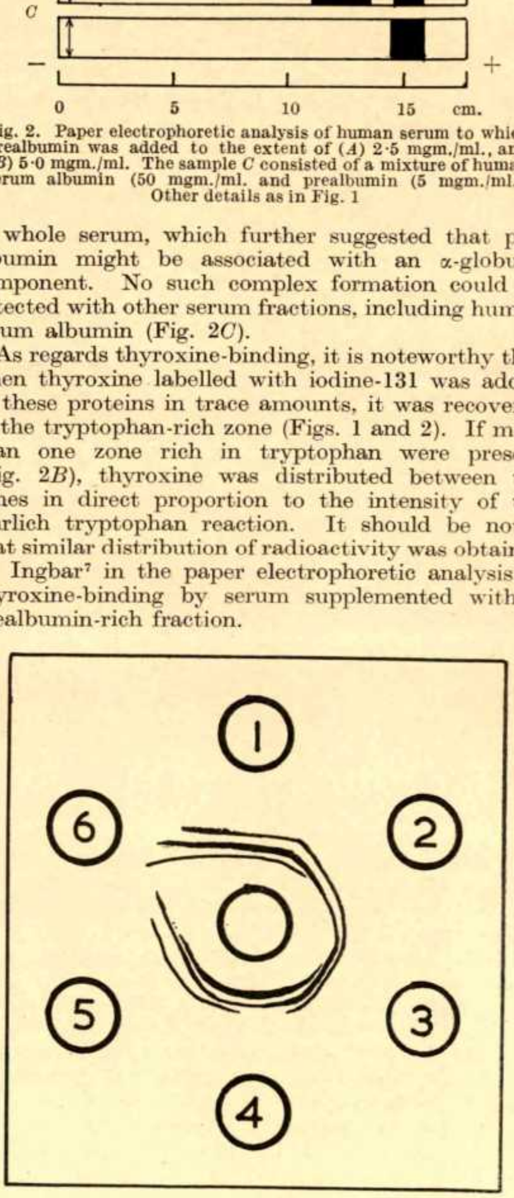

Fig. 3. Interaction between rabbit antiserum against human serum prealbumin (central well) and (1) prealbumin, (2) thyroxine-binding protein eluate from electrophoretic separation of whole serum, (3) Cohn fraction IV-4, (4) ten-fold concentrate of human amniotic liquor, (5) whole human serum, and (6) human serum albumin, according to Ouchterlony's (ref. 12) technique of diffusion in agar gel

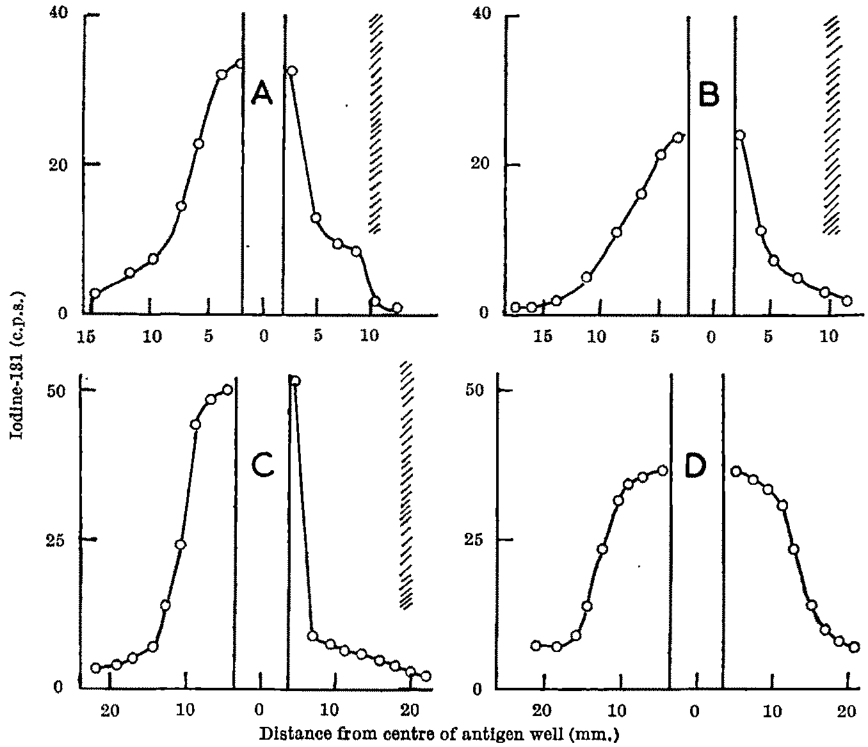

Fig. 4. Distribution of radioactivity in agar gel by a method of profile counting after the immunological reaction has occurred. Thyroxine labelled with iodine-131 was added to all samples tested against rabbit anti-prealbumin antiserum. (*A*) prealbumin (1·0 mgm./ml.); (*B*) whole serum (four-fold dilution); (*C*) thyroxine-binding protein eluate corresponding to 1 ml. of serum; (*D*) human serum albumin (20 mgm./ml.). The hatched bars indicate the position of the precipitate formed after 48 hr. The position of the well containing rabbit anti-human prealbumin antiserum was to the right of the antigen well in the diagram

The second approach to the problem was an immunological one. By using Ouchterlony's[12] technique of diffusion in agar gel (Fig. 3), the following protein fractions reacted with rabbit antiserum against human serum prealbumin to give one or more of the three precipitation lines (depending on the antigen concentration) observed with prealbumin: (*a*) whole human serum; (*b*) Cohn fraction IV-4; (*c*) eluate of thyroxine-binding protein in the α-globulin fraction obtained from whole serum by electrophoresis on a cellulose column[13] (after marking it with a trace of thyroxine labelled with iodine-131); (*d*) a ten-fold concentrate of human amniotic liquor, which also possesses a tryptophan-rich component intermediate between the α_1- and α_2-globulins in paper electrophoresis that exhibits intense thyroxine binding[14]. Human serum albumin (Lister) at various concentrations did not show any reaction with the anti-prealbumin serum under similar conditions.

Finally, strong evidence that one at least of the prealbumins present in thyroxine-binding protein is responsible for the binding of thyroxine was obtained from profile counting of the radioactivity[15] in agar gels after marking the test samples with a trace of thyroxine labelled with iodine-131 (0·03–0·08 μgm./ml.).

In the absence of a reaction with antibody, the distribution of radioactivity on either side of the antigen well is symmetrical, whereas if precipitation occurs the antigen does not diffuse freely on the side of the antibody, so that the profile counts show asymmetry.

As Fig. 4 shows, the pronounced asymmetry found in the distribution of radioactivity after reaction with anti-prealbumin serum indicates that most of the thyroxine in whole serum, in Cohn fraction IV-4 and in eluate of thyroxine-binding protein from whole serum was bound to the prealbumin component. The absence of any accumulation of radioactivity in the zone of the antigen–antibody precipitate can be explained by supposing that the reaction between prealbumin and anti-prealbumin results in the liberation of thyroxine originally bound to prealbumin. Evidence that this does, in fact, occur will be presented elsewhere. The symmetrical distribution of radioactivity and the absence of a precipitation line with albumin (Fig. 4*D*) further demonstrates the lack of prealbumin in this fraction and indicates that albumin binds thyroxine independently of prealbumin.

It is concluded from these experiments that a large part of human serum prealbumin is present as a complex in the α-globulin fraction and that it is responsible for the binding of thyroxine observed in thyroxine-binding protein. Other questions have arisen from this work, such as the identity of the component associated with prealbumin and whether the thyroxine-binding of the complex is greater than that of its individual components. Attempts to resolve these problems and full experimental details will be described elsewhere.

I am indebted to Dr. A. C. Allison for valuable advice and help throughout this investigation. I also wish to thank Prof. H. E. Schultze for generous supplies of human serum prealbumin and immune rabbit serum, Dr. D. R. Bangham for human amniotic liquor and Dr. S. H. Ingbar for Cohn fraction IV-4.

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LETTERS TO THE EDITORS

CRYSTALLOGRAPHY

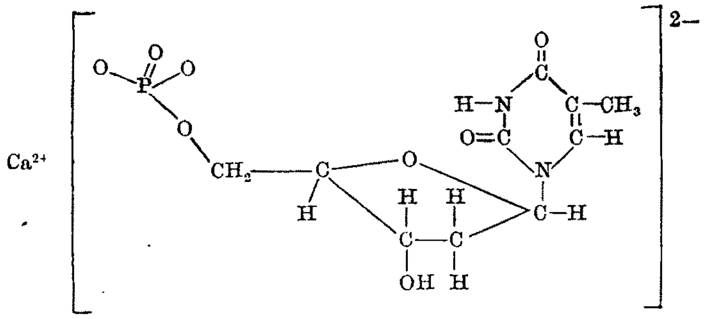
Crystal Structure of Calcium Thymidylate

NUMEROUS recent observations, both biological and chemical, have indicated that deoxyribonucleic acid is very probably the substrate which serves to store and transport genetic information. The initial formulation of this hypothesis brought forth a variety of structural speculations aimed at linking the biological role of deoxyribonucleic acid to its molecular structure. The most interesting and successful model was proposed by Crick and Watson[1]; it has since been supported by many other studies.

However, the success of this model should not be allowed to obscure certain limitations inherent in the stereochemical assumptions of Crick and Watson. They assumed that the elementary units of which deoxyribonucleic acid is composed have essentially the same structure in the entire molecule as in crystals of individual degradation products. At present, the structures of about a dozen purine and pyrimidine bases are known[2-11], and in addition, the structures of two ribosides, cytidine[12] and 5′-bromo-5′-deoxythymidine[13], and one ribotide, adenylic acid[14], have been determined. Spencer[15] has recently emphasized the need for precise structural information about the components of deoxyribonucleic acid.

It thus appeared to us worth while to determine the crystal structure of a deoxyribotide, which is in effect one of the 'monomers' of deoxyribonucleic acid, so that direct evidence might be obtained of the mutual arrangement of the three fundamental groups: the phosphate, the sugar, and the base.

The calcium salt of thymidylic acid, which has the following structural formula, proved suitable for X-ray crystallographic analysis:



The salt was supplied to us by the California Foundation for Biochemical Research, and was recrystallized by careful evaporation of an aqueous solution. The crystal used for the X-ray work had approximate dimensions 1·5 mm. × 0·5 mm. × 0·2 mm.

Table 1. APPROXIMATE FRACTIONAL ATOMIC CO-ORDINATES

	x/a	y/b	z/c		x/a	y/b	z/c
Ca	0·041	0·500	0·926	O_{13}	0·154	0·500	0·106
P	0·090	0·002	0·810	O_{14}	0·200	0·740	0·340
O_1	0·062	−0·173	0·870	N_1	0·461	0·165	0·677
O_2	0·055	0·139	0·894	N_2	0·522	0·165	0·460
O_3	0·078	−0·033	0·668	C_1	0·251	−0·001	0·959
O_4	0·193	0·002	0·826	C_2	0·337	0·036	0·969
O_5	0·413	−0·034	0·860	C_3	0·342	0·258	0·951
O_6	0·328	0·335	1·077	C_4	0·445	0·296	0·905
O_7	0·616	0·161	0·657	C_5	0·468	0·163	0·826
O_8	0·441	0·171	0·268	C_6	0·530	0·161	0·605
O_9	0·133	0·500	0·712	C_7	0·436	0·165	0·405
O_{10}	0·314	0·666	0·687	C_8	0·362	0·169	0·477
O_{11}	0·059	0·301	0·524	C_9	0·265	0·173	0·404
O_{12}	0·087	0·003	0·223	C_{10}	0·371	0·160	0·606

X-ray photographs were taken with both Weissenberg and precession cameras and copper $K\alpha$ radiation. The dimensions of the monoclinic unit cell are: $a = 14{\cdot}40 \pm 0{\cdot}02$ A., $b = 6{\cdot}87 \pm 0{\cdot}01$ A., $c = 9{\cdot}81 \pm 0{\cdot}01$ A., and $\beta = 90° 58' \pm 3'$. The only systematic extinctions, $0k0$ with k odd, lead uniquely to the space-group $P2_1$ for this optically active molecule. The density of the crystal, measured by flotation in a mixture of 'Freon 113' and bromoform, lies between 1·58 and 1·61 gm./cm.^{3}; the density calculated on the assumption that the unit cell contains two molecules of calcium thymidylate, each accompanied by 6 molecules of water, is 1·60 gm./cm.^{3}.

Intensity photographs were taken by the equi-inclination Weissenberg method for the layers $k = 0$ to 5 and $l = 0$ to 8. The multiple film method was used and corrections were made in the usual way, although no absorption correction was applied. All diffraction maxima for which $s = \frac{2 \sin\theta}{\lambda}$ is less than 1·17 A.$^{-1}$ were measured; of the total of 1,788 reflexions, 214 were too weak to be observed.

The structure determination was first begun in Strasbourg with no other means of calculation than Beevers–Lipson strips. The Patterson projection on (010), together with certain general features of the diffraction photographs, gave the location of the calcium atom and the phosphate group, and permitted the approximate determination of the position and orientation of the sugar and the base. However, despite many attempts, uncertainties concerning individual atomic positions and especially the ignorance of the locations of the water molecules prevented our finding a trial structure sufficiently good to serve as the starting point for the usual convergence to a refined structure.

The structure was then resolved unambiguously from a sharpened three-dimensional Patterson function calculated on *Swac*[16]. By quantitative interpretation of this function we were able to determine the position of every atom of the molecule of calcium thymidylate and of several of the water molecules, although certain ambiguities remained with the latter at this stage. One round each of three-dimensional Fourier synthesis and of least squares have served to improve the atomic position and remove the ambiguities about the number and the positions of water molecules. Refinement of the structure is still in progress, but the atomic co-ordinates are now known with a precision which we estimate to be, on the average, better than 0·05 A. in x and z, and better than 0·1 A. in y. The approximate atomic co-ordinates are given in Table 1; O_9 to O_{14} are the six water molecules of the asymmetric unit.

Fig. 1 represents a projection of the electron density on the $x0z$ plane ; Fig. 2 is a projection of the structure on this same plane, while Fig. 3 is a projection of the structure on the plane $0yz$.

Even at this stage of refinement several conclusions can be drawn : (1) The arrangement of the phosphate group and the calcium atom relative to the two-fold screw axis is similar to that found by MacLennan and Beevers[17] for dicalcium phosphate. (2) All the atoms of thymine lie in a plane, essentially perpendicular to the b-axis. (3) The thymine molecules are packed together with their planes parallel to one another as in the model of deoxyribonucleic acid form B. Furthermore, the distance between the two bases ($b/2$ = 3·43 A.) is nearly identical with that found in deoxyribonucleic acid (3·40 A.). (4) The sugar is in the normal gauche form ; in addition, its plane is essentially perpendicular to the plane of the thymine residue, which confirms the result found by Furberg[12] for cytidine. (5) The structure is interlaced with a network of at least nine possible satisfactory hydrogen bonds, all but one of which involve at least one water molecule.

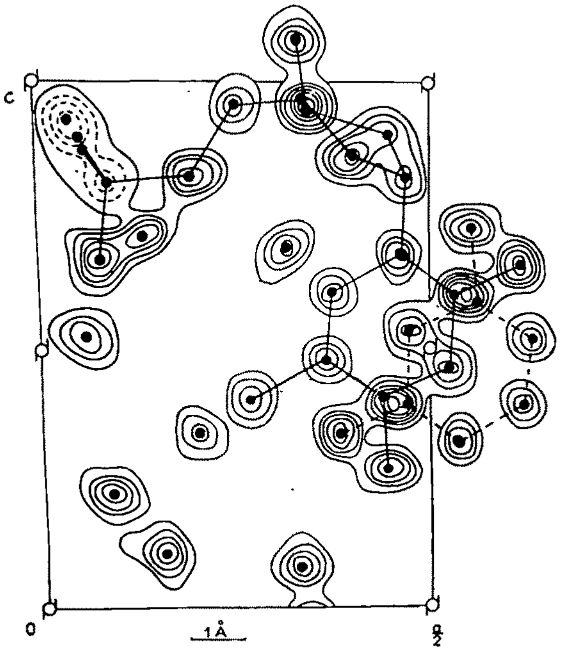


Fig. 1

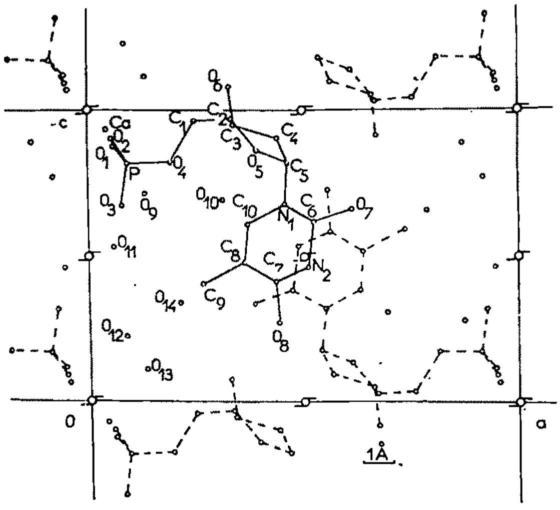


Fig. 2

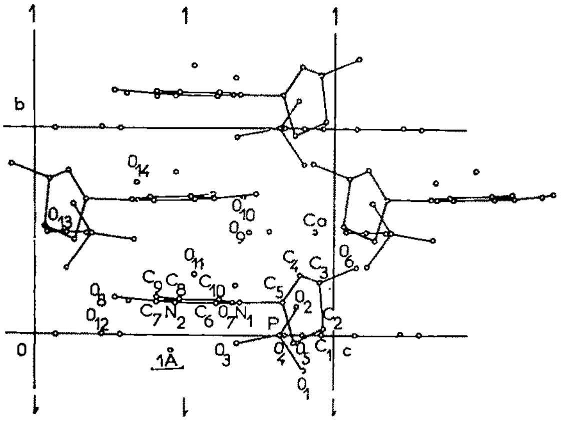


Fig. 3

We are grateful to the United States Office of Naval Research for support of the computer *Swac* upon which all the later stages of the present calculations were done.

P. Horn
V. Luzzati
Centre de Recherches sur les Macromolecules,
Strasbourg.
K. N. Trueblood
University of California,
Los Angeles. Feb. 11.

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PHYSICAL SCIENCES

A New Value for the Earth's Flattening, derived from Measurements of Satellite Orbits

In a recent article[1] in *Nature*, we described how the Earth's gravitational field could be explored with the aid of satellites, and gave some results obtained from analysis of kinetheodolite observations of *Sputnik* 2 (1957β), the orbit of which was inclined to the equator at an angle near 65°. From observations of a single satellite, the coefficient J of the second harmonic in the Earth's gravitational potential could only be evaluated if the coefficient D of the fourth harmonic were given its conventional value of $10 \cdot 6 \times 10^{-6}$. On this assumption the value derived[1] for J was 1626×10^{-6}, corresponding to a value of 1/298·1 for the Earth's flattening (defined as the difference between equatorial and polar radii, divided by the equatorial radius), as compared with the previously accepted value[2] of 1/297·1. To obtain J and D independently, results from two satellites, of substantially different orbital inclinations, are required.

Accurate information is now available[3] for the rate of rotation of the orbital plane of the *Vanguard* 1 satellite (1958 β 2), the orbital inclination of which is near 34°. Combining the data from *Sputnik* 2 and *Vanguard* 1, we find $J = (1624{\cdot}6 \pm 0{\cdot}3) \times 10^{-6}$, $D = (6 \pm 1) \times 10^{-6}$. The corresponding value for the Earth's flattening is $1/(298{\cdot}20 \pm 0{\cdot}03)$. The standard deviations quoted are those arising from observational errors, and it is possible that somewhat larger errors may occur, because higher-order harmonics in the Earth's gravitational field have been ignored. The coefficient most likely to cause such errors is that of the sixth harmonic, J_6 in the notation of our previous article. We have now made a preliminary estimate of J_6 with the aid of the information so far available on *Explorer* 4 (1958ε), the inclination of which is near 50°, and find $J_6 = (0{\cdot}1 \pm 1{\cdot}5) \times 10^{-6}$: this causes no significant change in the values of J, D and flattening already quoted. Nor is there any significant change if the coefficient of the third harmonic J_3, derived recently[4] from perturbations to the orbit of *Vanguard* 1, is taken into account.

D. G. KING-HELE
R. H. MERSON

Royal Aircraft Establishment,
Farnborough, Hants. Feb. 25.

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Heat-Flow Values from the South-Eastern Pacific

PRIOR to these new measurements, twenty-five heat-flow values from the Pacific Ocean Basin and eight from the Atlantic have been published[1]. The surprising fact brought out by these measurements is the approximate equality of average heat flow of the oceanic and continental areas, about 1×10^{-6} cal./cm.^{2} sec. This result was unexpected on the basis of values of radioactivity indicated for typical continental and oceanic crustal rocks existing near the Earth's surface. It has usually been assumed that most of the surface heat flow in continental regions must originate in the relatively thick and radioactive continental crust. Under the oceans, nearly all the average heat flow must come from the mantle beneath the relatively thin oceanic crust.

The new heat-flow values from the Pacific were obtained during October 1957–February 1958 on the Scripps Institution of Oceanography *Downwind* International Geophysical Year Expedition. The measurements are listed in Table 1, and the geographical distribution of stations, with generalized 4,000- and 5,000-m. bottom-depth contours of the area, is shown in Fig. 1. The topography was kindly supplied by Dr. Henry Menard of the Scripps Institution of Oceanography. The field technique was to measure the temperature gradient in the upper few metres of ocean floor sediment with apparatus first described by Revelle and Maxwell[2], and also the thermal conductivity of a cored sample of this sediment by a transient method[1]. The resulting heat-flow values are most probably accurate within 10 per cent, unless otherwise noted. The 'less than' or 'greater than' signs indicate the uncertainty of imperfectly functioning apparatus, usually due to an uncertainty of depth of penetration of the temperature gradient probe into the ocean floor. The thirty-six new measurements comprise a relatively more detailed study in a somewhat limited area, compared to the previous measurements.

When the new heat-flow values are considered together with the previous measurements in the Pacific, some interesting features can be seen. (1) The East Pacific Rise, a broad elevated region of the eastern Pacific sea floor, appears to be associated with a relatively narrow band of high heat flow for at least 6,000 km. along its length. This was indicated by three stations of the previous Pacific measurements[1], and is represented by stations 7, 8, 9, 10, 27, 29, 31 and 32 of the present study. (2) The axes of the trenches bordering the eastern Pacific Ocean appear to be associated with low heat flow. The previous Pacific measurements indicated this for the trench off Central America. Stations 18, 19, 20 and 21 respectively, of the present measurements, represent a series of heat-flow values down the eastern flank of a part of the South American trench, with the last two measurements in the deepest part. Station 17 is just west of the western flank of the same trench. (3) There seems to be fair evidence for areas with low heat flow roughly paralleling, and to each side of, the high heat-flow band of the East Pacific Rise. To the west, the low heat-flow area is represented by stations 1, 2, 5, 6, 35, 36 and one of the previous Pacific measurements. To the east of the Rise, the evidence for a low is not as good, being

Table 1. HEAT-FLOW MEASUREMENTS

Station No.	Heat flow (10^{-6} cal./cm.^{2} sec.)	Depth (m.)	Latitude	Longitude	Station No.	Heat flow (10^{-6} cal./cm.^{2} sec.)	Depth (m.)	Latitude	Longitude
1	0·14	4,450	1° 23′ S.	131° 31′ W.	19	1·07	3,700	12° 54′ S.	78° 06′ W.
2	$0{\cdot}52 < Q < 0{\cdot}78$	4,510	14° 59′ S.	136° 01′ W.	20	0·17	5,950	12° 38′ S.	78° 38′ W.
3	0·97	4,760	21° 40′ S.	147° 41′ W.	21	0·17	5,900	12° 59′ S.	78° 21′ W.
4	1·1	5,120	40° 37′ S.	132° 52′ W.	22	0·26	4,220	18° 26′ S.	78° 16′ W.
5	0·14	4,620	42° 16′ S.	125° 50′ W.	23	0·98	3,090	18° 20′ S.	79° 21′ W.
6	0·73	4,140	46° 44′ S.	123° 18′ W.	24	1·02	4,230	19° 01′ S.	81° 29′ W.
7	2·06	3,180	44° 27′ S.	110° 44′ W.	25	2·12	3,880	27° 04′ S.	88° 53′ W.
8	3·06	3,180	43° 43′ S.	107° 33′ W.	26	0·23	3,200	28° 00′ S.	96° 20′ W.
9	2·09	3,850	43° 44′ S.	104° 25′ W.	27	4·54	2,910	27° 55′ S.	106° 57′ W.
10	2·30	4,580	42° 44′ S.	96° 03′ W.	28	$1{\cdot}64 < Q < 1{\cdot}89$	3,500	23° 15′ S.	117° 48′ W.
11	1·0	3,310	41° 06′ S.	86° 38′ W.	29	7·66	3,060	14° 44′ S.	112° 06′ W.
12	$>0{\cdot}89$	4,110	23° 23′ S.	72° 10′ W.	30	1·01	3,580	13° 30′ S.	108° 31′ W.
13	0·80	3,750	23° 28′ S.	72° 58′ W.	31	8·09	3,280	11° 39′ S.	109° 48′ W.
14	1·62	4,550	21° 33′ S.	79° 09′ W.	32	7·95	2,840	9° 55′ S.	110° 39′ W.
15	0·79	2,340	20° 49′ S.	81° 08′ W.	33	0·87	4,040	5° 56′ S.	112° 29′ W.
16	1·54	2,400	20° 48′ S.	81° 09′ W.	34	1·71	4,330	3° 40′ S.	114° 13′ W.
17	1·46	4,440	13° 35′ S.	79° 09′ W.	35	0·56	3,810	1° 28′ N.	116° 04′ W.
18	2·72	2,260	12° 49′ S.	77° 53′ W.	36	0·43	4,200	4° 06′ N.	115° 41′ W.

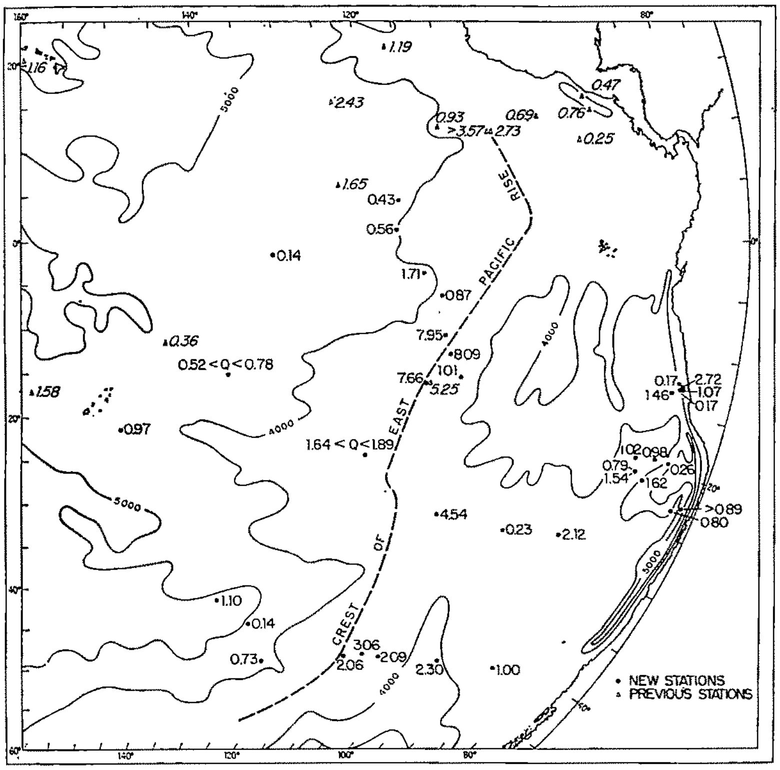

Fig. 1

represented only by station 26 and several of the previous Pacific measurements off the coast of Central America. The number of heat-flow measurements is not yet sufficient to establish how the trenches fit this general pattern; but the rough parallelism of the Rise and trenches may suggest a relationship.

An interesting result of these measurements is the extreme range of the heat-flow values, which extend from a low of $0 \cdot 14 \times 10^{-6}$ cal./cm.^{2} sec. to a high of $8 \cdot 09 \times 10^{-6}$ cal./cm.^{2} sec., a ratio of more than 1 : 50. Even though the area studied has large topographic features, where differences of heat flow might be expected, the large magnitude of the range of heat flow is somewhat surprising. It is believed that some of the variation in heat flow may be due to irregularities in bottom topography, or to an irregular surface of rocks of good thermal conductivity buried by a smooth sediment surface, as suggested previously[1]. Although it is difficult to evaluate the combined magnitude of these effects, it appears that they would not alter the observed heat flow at any station from the assumption of heat flow through uniform, horizontal layers by more than a factor of two, and would not be systematically distributed. The measurements have not been corrected for these disturbances, but irregular bottom topography may have had some effect on stations 6, 10, 11, 15, 16, and 30.

Undoubtedly, most of the variations observed in oceanic heat flow are due to differences in flow of heat from the mantle of the Earth. The pattern of heat flow in the eastern Pacific, if verified by further measurements, is suggestive of a large convective cell in the upper mantle of the Earth. The rising part of the convection cell, bringing hot material near the surface, may be represented by the East Pacific Rise, and the sinking parts by the possible low heat-flow areas on each side. Indeed, the lowest heat flows measured may be due entirely to the small amount of heat generated by radioactivity in the crust, with little or no heat coming from the mantle. The oceanic heat-flow values also show variations of relatively small horizontal extent not associated with topographic variations or with the large pattern, suggesting smaller-scale thermal anomalies in the mantle, perhaps also due to convection. A more closely spaced series of measurements in one of these areas is highly desirable.

Similar patterns may be expected for other areas of the Earth; high heat flow has been indicated also for the mid-Atlantic Ridge (Sir Edward Bullard, personal communication), a topographic feature of the Atlantic Basin similar to the East Pacific Rise. However, since convection could be driven by a deep distribution of radioactive heat sources under the ocean areas, it may be that similar patterns would not be observed in continental regions, where the radioactivity may be frozen uniformly in a relatively shallow crust. In fact, while the average heat flow seems to be about the same over continental and oceanic regions, the continental values show considerably less variation than the oceanic. However, this may result from a more limited distribution of continental heat-flow values; in fact, some areas of continents have been recently investigated which show unusually high heat flow[3,4]. Many problems have yet to be solved, and towards this end it is hoped that the results herein will be a stimulus for further measurements.

The measurements were made possible with the facilities of the Scripps Institution of Oceanography, and the interpretation of field observations was facilitated by a grant from the Institute of Geophysics, University of California. I wish to thank Prof. R. W. Raitt for encouraging the investigation and for many helpful discussions.

R. Von Herzen

Scripps Institution of Oceanography,
La Jolla, California.

Feb. 13.

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Improvement of the Fatigue Strength of Notched Specimens by artificially induced Residual Stresses

The question of whether or not residual stresses have any significant effect on fatigue strength has been the subject of much research for some time. However, in 1956 Puchner[1] showed that a large increase in the fatigue strength of specimens containing discontinuous longitudinal welds could be obtained by heating the specimen locally with an

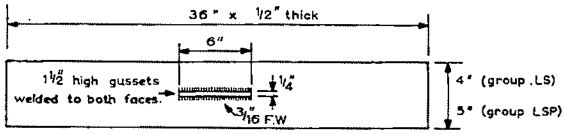
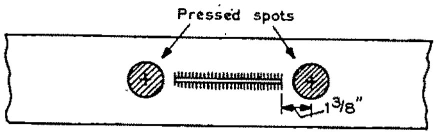
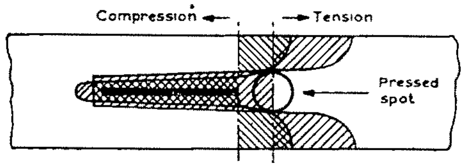


Fig. 1. Details of test specimens



(a) Positions of compressed areas.



(b) Qualitative residual stress distribution due to pressing

Fig. 2

oxyacetylene torch, in such a way as to introduce residual compressive stresses at the site of the most dangerous notch from the point of view of fatigue failure (namely, at the ends of the welds). His results have been confirmed by recent work of the British Welding Research Association. In view of the potential practical importance of these results, it was decided to carry out an exploratory programme of tests to determine the effect of inducing residual stresses by mechanical means.

The specimens used in this investigation were fabricated from mild steel to British Standard 15, having a yield stress of 18·0 tons/in.^{2} and an ultimate tensile strength of 28·5 tons/in.^{2}. They consisted of flat strips with a single short longitudinal stiffening gusset fillet welded centrally on each face so that the two gussets were opposite each other (Fig. 1). Specimens in group *LS* formed a control series and were tested in the as-welded condition, but those in group *LSP* were compressed locally between $1\frac{3}{4}$-in. diameter dies in the position indicated in Fig. 2. The total load between the dies was 315,000 lb. which is equivalent to an average compressive stress of 58·5 tons/in.^{2}. Fig. 2 also shows, qualitatively, the residual stress distribution induced by the local compression, and it will be seen that the notches at the extremities of the welds were in areas of high longitudinal compressive stress.

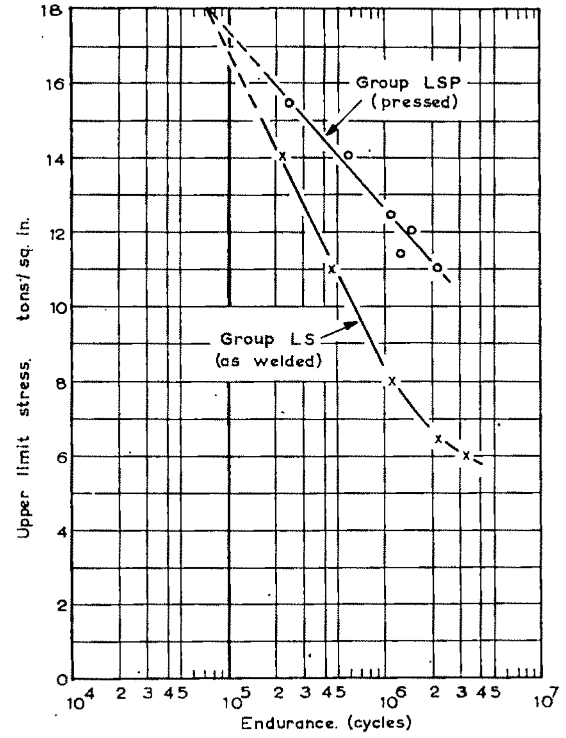


Fig. 3. Results of fatigue tests

All the specimens were tested under axial loading with a pulsating tension load cycle with a lower limit of zero, and the results obtained are shown in Fig. 3. It will be seen that for group *LS* the upper limit stress for an endurance of 2×10^6 cycles was 6·5 tons/in.^{2}, but that for group *LSP* this was increased to 11 tons/in.^{2}. An interesting point is that the two stress–endurance curves tend to converge at 18 tons/in.^{2}, the yield stress of the material. This was to be expected if the increase in fatigue strength were due to the induced residual stresses, since an applied tensile load of yield-point magnitude would result in 'mechanical stress relief' and eliminate their effects.

Thus it appears that specimens having clearly defined probable points for the initiation of fatigue failure can have their fatigue strength increased by compressing an area adjacent to the notch to such an extent that residual stresses are induced. The compressed area should be chosen so that the residual radial compressive stresses act in the same direction on the notch as the applied stresses. Further work is proceeding on this subject and this will be published elsewhere in due course.

T. R. GURNEY
British Welding Research Association,
Abington Hall,
Abington,
Cambridge.
Dec. 17.

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Thermal Decomposition of Irradiated Solids

THE thermal decomposition, *in vacuo*, of potassium permanganate[1] and silver permanganate[2] crystals is markedly affected by pre-irradiation in *Bepo* or in a cobalt-60 hot-spot. The induction periods are shortened and the maximum velocities are increased. A mechanism has been suggested involving the growth of decomposition spikes and the accumulation of strain in the crystal over the induction period.

Similar work in progress in these laboratories has shown that cæsium and rubidium permanganates are affected in a like manner. However, pre-irradiation of silver oxide[3] in *Bepo* in a position near the outside (thermal neutron flux, 2×10^{11} n./cm.^{2}/sec.) for 48 hr., in a hollow uranium slug (fast neutron flux, 3×10^{11} n./cm.^{2}/sec.) for one week, and in a cobalt-60 hot-spot (dose-rate, $1\cdot6 \times 10^6$ rep hr.$^{-1}$) for 48 hr., produced no effect on the subsequent thermal decomposition; the pressure – time curves of irradiated and unirradiated specimens were almost superimposable.

Insufficient work has, as yet, been done in this field of research to draw any definite conclusions as to the class of solids which will be affected by pre-irradiation. However, certain characteristics are observable.

Garner and Moon[4] bombarded barium azide with the radiations from radium at room temperature with no effect on the subsequent thermal decomposition. Similarly, they found no effect on the decomposition of mercury fulminate.

Bowden and Singh[5] subjected lithium azide, lead azide, silver azide, cadmium azide, and silver acetylide to bombardment by electrons, thermal neutrons, fission products, and X-rays. The thermal decomposition of lithium azide was effected by thermal neutron bombardment (approx. dose, $2 \cdot 5 \times 10^{11}$ nvt) in a manner similar to that found for potassium permanganate, whereas cadmium and lead azides were only slightly affected. The published results for the last two substances, however, do not indicate the degree of reproducibility of results and the change could be due to experimental variation. No effect was found in the decomposition of silver azide. This substance melts on decomposition.

Simpson *et al.*[6] pre-irradiated ammonium dichromate with cobalt-60 γ-rays for four months. The intensity of the radiation was not given, but was stated to be low. The subsequent thermal decomposition showed an induction period only slightly less than normal, and the rate constant, k_1, for the acceleratory region changed from 0·0175 to 0·023, as calculated from the Prout–Tompkins equation[7], $\log_{10} p/(p_f - p) = k_1 t + c_1$, where p_f is the final pressure. The decompositions were stated to be reproducible to within only 20 per cent and it appears possible that this last difference might be attributed to other factors.

Flanagan[8] subjected lead styphnate monohydrate to a γ-ray dose of $1 \cdot 8 \times 10^6$ r. from cobalt-60 and found no effect on the thermal decomposition. Reactor irradiation, however, greatly affected the subsequent decomposition—the maximum rate of decomposition was increased three-fold by a neutron dose of $2 \cdot 2 \times 10^{18}$ nvt. The absence of any effect by γ-ray irradiation and the fact that significant changes were obtained only after heavy doses of neutrons ($> 10^{17}$ nvt) would suggest an irradiation effect different from that found with the permanganates where a dose of only 6×10^{13} nvt caused pronounced changes in the thermal decomposition.

The pressure–time plots of potassium, silver, cæsium, and rubidium permanganates and ammonium dichromate can be represented by the Prout–Tompkins equation or a modification of this equation[9]. The decomposition mechanisms associated with these equations involve the concept of branching chains. No analysis was given by Bowden and Singh of the pressure–time curves for lithium azide, but using the values obtained from a photographic enlargement of the published curve a good fit is obtained by the application of the Prout–Tompkins equation.

The power law, $p = k_2 t^n + c_2$, is obeyed for the decompositions of lead azide, lead styphnate monohydrate, mercury fulminate, silver oxide, and barium azide. Growth of nuclei in these cases is presumed to be normal and the effect of possible overlap between growing nuclei is not considered.

The theory proposed for the decomposition of irradiated potassium and silver permanganates postulates the displacement of potassium and silver ions into interstitial positions. The failure to observe any significant change in the length of the induction period (and perhaps k_1) in the decomposition of irradiated ammonium dichromate is due, possibly, to the presence of the more complex and not directly displaceable ammonium ion.

Thus, it would seem that the substances which are likely to be affected by pre-irradiation in the same way as the permanganates will be those containing a simple metal cation and decomposing according to a branching chain mechanism. Another requirement is that the decomposition spikes should create strain sufficient to crack or fracture the solid and thus create new, reactive surfaces.

The decomposition of lead oxalate[10] yields a typical sigmoid pressure–time curve which obeys the Prout–Tompkins equation. In view of the above observations an investigation of the effects of pre-irradiation on this substance is in progress.

E. G. Prout

Department of Chemistry,
Rhodes University,
Grahamstown,
South Africa.
Feb. 9.

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Errors caused by Partial Drying of Hardened Portland Cement during Testing

It is known that incorrect estimates of the modulus of rupture and tensile strength may be obtained if Portland cement mortar or concrete specimens awaiting test are allowed to dry partially. Strength changes have also been observed when pozzolana-lime cement specimens begin to dry out[1], and, similarly, it has been demonstrated[2] that temporary reductions can develop in the modulus of rupture of road-making concretes, over a period of days, if the hardened mass is subjected to drying conditions.

The purpose of this communication is to emphasize the extreme magnitude of the change in strength which can be caused by partial drying of hydrated Portland cement, and to direct attention to the great rapidity with which this change can occur.

The results given here were obtained with small Portland cement paste prisms of ½-in. square cross-section, which had been cured for an initial 24 hr. in the moulds, and afterwards under water at 73° F. until tested at 56 days. A type 1 high alkali Portland cement was used at a water/cement ratio of 0·28 by weight. The results came from tests carried out at a temperature of approximately 75° F., in a laboratory which was not air-conditioned. The relative humidity was low at the time. The moduli of rupture given in Table 1 were obtained as follows.

Each row of results was obtained with specimens removed from the curing water at the same time. Since each test occupied 45–60 sec., the figures in column (*a*) are for specimens the surfaces of which had dried for not more than 1 min.; those in column (*f*) apply to specimens which had been exposed for 4½–6

Table 1. MODULUS OF RUPTURE (LB./IN.^{2}) OF PORTLAND CEMENT PASTE AT 56 DAYS

	a	*b*	*c*	*d*	*e*	*f*
1	1,040	910	1,000	980	1,040	—
2	1,380	1,110	1,140	900	—	—
3	1,750	970	1,050	910	1,090	990
4	1,960	1,930	1,790	2,200	2,300	—
5	1,670	2,310	2,150	1,840	1,860	1,950
6	1,730	2,020	2,090	1,750	1,770	—

min. It was observed that specimens 2*a* and 3*a*, which were tested with the very minimum of delay, apparently had higher strengths than the other prisms in rows 1–3. Since differential drying shrinkage was considered a possible cause of this behaviour, the remaining experiments (rows 4–6 inclusive) were completed with the prisms immersed in a water-bath at 75° F. during testing. A mean modulus of rupture of 1,960 lb./in.^{2} and coefficient of variation of 10 per cent was obtained with immersed specimens. This compares with a mean of 1,010 lb./in.^{2} and coefficient of variation of 8 per cent for tests performed after more than 1 min. of exposure in the air of the laboratory.

Equally large strength reductions have since been observed in additional experiments with 3 in. × 3 in. × 18 in. Portland cement paste beams which were allowed to dry for a short period in the air of the laboratory prior to testing.

K. M. ALEXANDER*

Stanford Research Institute,
Menlo Park,
California.

Feb. 10.

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* Present address: Cement and Ceramics Section, Chemical Research Laboratories, Commonwealth Scientific and Industrial Research Organization, G.P.O. Box 4331, Melbourne C.1.

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CHEMISTRY

Structure of Glass

I HAVE shown[1,2] that there is a linear relation between the volume v associated with an oxygen ion in a glass and the composition of the glass. The relation for simple soda–silica glasses is:

$$v = 3\cdot8R + 14\cdot9 \qquad (1)$$

and for simple potash silica glasses:

$$v = 12R - 1\cdot2 \qquad (2)$$

where R is the number of oxygen ions per network-forming atom. v is modified by the introduction of a third oxide into soda or potash glass. Introduction of a network-forming oxide should be allowed for in the calculation of R and then v can be obtained from equations (1) or (2) with a slight modification of the additive constant (15·1 for glasses containing alumina and 14·6 for those containing beryllia). Boron trioxide causes a further correction and then:

$$v = 3\cdot8R - 2\text{Na}^* + 14\cdot65 \qquad (3)$$

Chemical symbols with an asterisk denote the number of gram-ions in 100 gm. of glass.

Introduction of certain cations in soda or potash glass contracts or expands the network proportionally to the concentration, each oxide having its own factor, which is constant over a wide range of compositions. The factors are different for soda and potash glasses, but they remain constant when several substances are introduced, that is, they do not influence each other. The factors in Table 1 have been determined.

Table 1

Ion	Radius (A.)	Factor for soda glass	Factor for potash glass
Li^+	0·70	− 2·4	−12
Na^+	0·98	0	− 2
K^+	1·38	+ 4	0
Rb^+	1·49	—	+ 4
Mg^{2+}	0·78	− 5	−13
Ca^{2+}	1·06	− 5	−12
Sr^{2+}	1·22	− 3	—
Ba^{2+}	1·43	− 0·5	− 9
Zn^{2+}	0·83	− 2	—
Pb^{2+}	1·32	+ 0·5	− 9
Fe^{2+}	0·83	− 4	—
Fe^{3+}	0·63	− 6·5	—
Bi^{3+}	1·24	− 9	—
Ti^{4+}	0·65	−11	—
Zr^{4+}	0·77	−10	—
Ta^{5+}	0·68	—	−36

The complete equation for glasses with a soda basis is therefore:

$$v = 3\cdot8R - 2\cdot4\text{Li}^* + 4\text{K}^* - 5\text{Mg}^* - 5\text{Ca}^* - 3\text{Sr}^* - 0\cdot5\text{Ba}^* - 2\text{Zn}^* + 0\cdot5\text{Pb}^* - 4\text{Fe}^{\text{II}*} - 6\cdot5\text{Fe}^{\text{III}*} - 9\text{Bi}^* - 11\text{Ti}^* - 10\text{Zr}^* + 14\cdot9 \qquad (4)$$

and for glasses with a potash basis:

$$v = 12R - 12\text{Li}^* - 2\text{Na}^* + 4\text{Rb}^* - 13\text{Mg}^* - 12\text{Ca}^* - 9\text{Ba}^* - 9\text{Pb}^* - 1\cdot2 \qquad (5)$$

It can be seen that the smaller the radius and the larger the valency of the ion, the greater its contracting effect; an expanding effect is rarer and is larger for an ion with smaller valency. The contraction of potash glasses, which have considerably larger v values, is much larger than that of soda glasses. The effect of ions which do not have a noble gas structure is smaller.

Calculations have been made for more than 500 glasses, including a few with 8 and one with 9 components. The largest discrepancy is 1·5 per cent; in most cases it is a few tenths of 1 per cent.

From the results in Table 1 we can deduce that:

(1) Li+ is not a network-forming ion, but a modifier; otherwise the calculations do not give a reasonable value for v (lithium oxide content 0–15 per cent).

(2) Zn^{2+}, Ti^{4+} and Zr^{4+} are also modifiers (titanium dioxide content 2·04–9·89 per cent, zinc oxide content 1·29–11·39 per cent, zirconium dioxide content 2·67–20·96 per cent).

(3) Be^{2+} is a network-former (beryllium oxide content 4·78–30·95 per cent).

(4) Al^{3+} is also a network-former (aluminium oxide content 0–25·3 per cent).

No ion has been found to have an intermediate behaviour.

These conclusions are confirmed by a calculation of the thermal expansion coefficients (α) on a new basis. It is well known that α can be calculated roughly by adding together the oxide percentages multiplied by appropriate factors. A number of different sets of factors exist[3,4], but none of them gives satisfactory results if used for widely differing glasses; the differences between measured and calculated values sometimes amount to more than 10 per cent and they are quite useless for borosilicate glasses. A new equation is suggested for the coefficient of linear expansion, which contains an additive constant besides the oxide percentages multiplied by new factors; the additive constant varies somewhat with temperature (this has scarcely been considered by former investigators). The new equation, between 0° and 100° C., is:

$$10^8\alpha = 100(Li_2O) + 35(Na_2O) + 30(K_2O) - 8(MgO) + 10(CaO) + 8(BaO) + 6(PbO) + 4(Fe_2O_3) - 6(ZnO) - 6(ZrO_2) + A \quad (6)$$

where the additive constant A is 200 for common glasses (containing less than 5 per cent of lead, barium or zinc oxides), 280 for glasses with more than 5 per cent lead oxide, 220 for glasses with more than 5 per cent barium oxide and 250 for glasses with more than 5 per cent zinc oxide, between 0° and 100° C. The thermal expansion coefficients of more than 220 glasses have been calculated in this way; the average error in the different series varies from 0·7 per cent to 2·2 per cent for boron-free glasses, 2·5 per cent for borosilicate glasses and 3·5 per cent for glasses containing titanium dioxide.

A very striking fact is that the thermal expansion is largely due to the alkali ions; the effect of alkaline earth ions is small, while that of Fe^{3+}, Zn^{2+} and Zr^{4+} is even smaller. All other ions have a negligible influence on the thermal expansion; the network-forming ions are without any effect. The oxides of beryllium and aluminium behave in this respect quite like silica, boron trioxide and phosphorus pentoxide.

The existence of a continuous non-periodic tetrahedral network seems to be indicated by these results, although the rigorous conditions proposed by Zachariasen[5] cannot be maintained in some cases.

I. NÁRAY-SZABÓ

Central Chemical Research Institute,
Hungarian Academy of Science,
114 Hungária körut,
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Estimation of Strontium in Animal Bone using X-ray Fluorescence Analysis

PREVIOUS work on strontium estimation in biological material has involved the use of optical emission spectroscopy[1] and flame spectrophotometry[2], both of which suffer from the disadvantage that the sample is destroyed during the analysis. This can be a significant factor when, in the interest of precision, the analysis must be repeated several times on each sample, when the quantity of material from any particular region of a bone is small, or when the sample is to be used for radiometric estimation of strontium-90.

X-ray fluorescence spectroscopy offers a fairly straightforward method for the estimation of strontium in animal bone, because the spectra of the major constituents, calcium and phosphorus, do not interfere with the strontium $K\alpha$ spectral line used in this analysis; and any of the heavier elements which may interfere are present in such small concentration that their effects can be ignored.

As a consequence of these two factors, no internal comparison element is necessary, and a direct measurement of intensity on the strontium $K\alpha$ line is sufficient to give the concentration of strontium.

Discounting instrumental error, the accuracy of the method will depend upon obtaining the maximum intensity of the fluorescence radiation, and upon the absolute reproducibility of the method of specimen preparation. This latter factor ensures that variations in intensity of the strontium $K\alpha$ radiation are due to variations in concentration and not to differences in the specimen surface exposed to the incident beam.

To obtain these two requirements the following method of specimen preparation was evolved.

A 2-gram sample of bone ash was ground to − 200 mesh, 2 drops of flexible collodion added as a binder, and the whole ground in acetone to achieve a uniform distribution. The dried powder was then compressed in a suitably shaped die, using a sheet of polished high tensile steel for the working face of the specimen, to a pressure of eight tons. The resultant disk has sufficient strength to be self-supporting, and offers an exactly identical surface to the X-ray beam in every sample, giving the desired specimen reproducibility.

The high compression also ensures that a maximum quantity of material is available at the immediate surface for the generation of secondary radiation. Because the sample is self-supporting its surface can be placed directly in the primary beam; no 'Mylar' film or other supporting medium is necessary. As a result the maximum intensity can be obtained.

The standards used in the construction of the working curve were made from human bone ash to which increments of strontium were added in the form of an aqueous solution of strontium nitrate, containing 0·2415 gm. in 100 ml. of water, giving a solution containing 1,000 p.p.m. To 19·9517 gm. of human bone ground to − 200 mesh was added 20 ml. of this solution. To achieve a uniform distribution of strontium, 100 ml. of acetone was added, and the whole mixed thoroughly until dry. This gave 20 gm. of bone ash containing 1,000 p.p.m. of strontium in addition to its normal strontium content.

This bulk material was diluted with bone ash to give 2-gm. standards of 100–800 p.p.m. in increments of 100 p.p.m., which were pressed into disks by the previously described method.

The intensities of the strontium $K\alpha$ line and background were measured for each sample. The intensity of the line was also measured in the same manner on a bone sample to which no strontium had been added. The intensity for the added strontium in each standard was then obtained by subtracting the background intensities and the strontium $K\alpha$ intensity of the bone standard.

The instrumentation used was: Philips X-ray spectrograph *PW*1520; quartz analysing crystal; Geiger counter operating at 1,700 V.; X-ray path evacuated; tungsten target, 50 kV. 20 m.amp.

The method of 'constant accuracy' counting was used, and 32,000 counts were taken on both the strontium line and the background on each sample. At the intensities under consideration the dead-time losses for the counter are so small that they can be ignored.

From the data obtained a curve was plotted by the least-squares method, and the standard deviation for the individual readings calculated from the method described by Youden[3]. The curve is shown in Fig. 1. The standard deviation is 8 p.p.m.; for 95 per cent confidence limits the standard deviation will be 16 p.p.m.

For the actual analyses the samples were run in triplicate, so that for 95 per cent confidence limits the standard deviation will be ± 10 p.p.m.

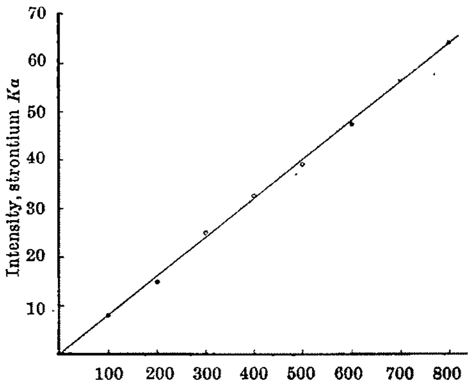

Fig. 1

Some results for bones of two adults labelled Adult 1 and Adult 2 are given in Table 1.

Table 1

Adult 1	Strontium (p.p.m.)	Adult 2	Strontium (p.p.m.)
Rib	286		
Vertebra	266		
Femur:		Femur:	
Epiphysis section *A*	281	Epiphysis section *A*	480
,, ,, *B*	276	,, ,, *B*	470
,, ,, *C*	287	,, ,, *C*	497
Shaft	291	Shaft	472

I wish to thank Dr. P. Ilbery, of the School of Public Health and Tropical Medicine, at whose request this investigation was carried out, for his co-operation throughout the project, Mr. W. J. Thomas, of the Bureau of Mineral Resources, for his valuable assistance in the statistical analysis, and Miss Horsford, of the School of Public Health and Tropical Medicine, for the careful preparation of the bone samples used in this work.

W. M. B. ROBERTS

Bureau of Mineral Resources,
Canberra.
Feb. 10.

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Micro Determination of Calcium

Hildebrand and Reilly[1] have recently described a complexometric titration method for the determination of calcium: the indicator used, 'Calcon', is superior to 'Solochrome' black in that calcium can be determined independently of magnesium, and, unlike the murexide method, a sharp end-point is obtained. All three methods employ ethylenediamine tetraacetic acid. The purpose of the present communication is to direct attention to the facts: (*a*) that the allied compound 1-(1-hydroxy-2-naphthylazo)-5-nitro-2-naphthol-4 sulphonic acid sodium salt (Eastman-Kodak) appears to be just as suitable as an indicator as 'Calcon' but is considerably cheaper; (*b*) that the method can also be used on an ultra-micro scale. Concentrations of the order of 10^{-2} µgm. calcium have been determined in volumes of about 40λ of solution with an accuracy of 1 per cent (1λ = 0·001 ml.).

Essentially, the method is similar to the original[1], and relatively the same quantity of buffer (diethylamine) is employed; in fact, it was found that the quantities of both buffer and indicator were critical. For 40λ of solution 1·75 ± 0·25λ of diethylamine maintained the required *p*H of 12–13, and accurate and repeatable results were obtained with 5 ± 0·5λ of indicator: these volumes were delivered with microburettes.

The cap of a 1-cm. 'attached-cap' polythene tube was found superior to a waxed slide for the titration: not only is the surface suitable, but also, lighted from below, the drop of solution is very suitably illuminated for observation of the end-point. The solution was brought into contact with the glass needle of the burette, a 100-λ pipette graduated in 1λ units (Glen-Creston, Ltd.), and titration continued until all trace of pink had disappeared and the solution turned pale blue[1]: at this stage the addition of 0·5λ of 0·0002 *N* ethylenediamine tetraacetic acid produced a marked change of colour. Stirring was carried out by a fine jet of air.

The stock solution of 0·02 *N* ethylenediamine tetraacetic acid keeps for many months without deterioration: however, the 0·0002 *N* solution prepared from it for titration was less stable and was therefore freshly prepared each week.

Determinations on twenty-one 40-λ samples containing $7{\cdot}96 \times 10^{-3}$ µgm. calcium diluted from a gravimetrically standardized solution gave a mean value of $7{\cdot}90 \pm 0{\cdot}80 \times 10^{-3}$; the difference is therefore less than 1 per cent from the expected value, and is far from statistical significance ($P > 0{\cdot}7$). Six or fewer determinations with a series of solutions of greater calcium concentration gave mean values which, as shown in Fig. 1, were also very close to those expected. Mean values were usually within 2 per cent, and never more than 4 per cent from the known values.

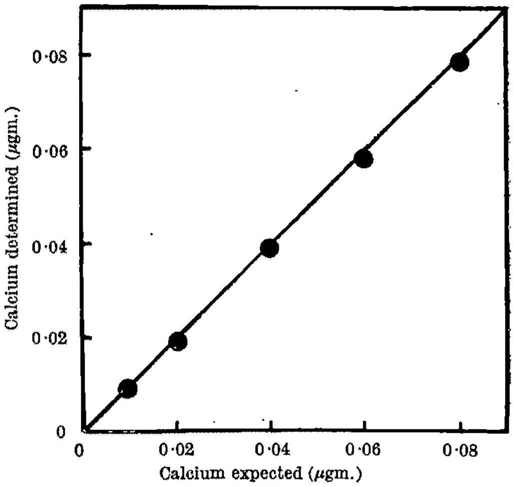

Fig. 1. Continuous line represents expected values. Closed circles are mean values of, from left to right, 21, 3, 3, 5 and 6 determinations of 40-λ samples

This work is part of a programme of research on the hatching of the potato root eelworm; a grant from the Nuffield Foundation is gratefully acknowledged.

A. B. GILBERT

Department of Zoology,
King's College,
University of Durham,
Newcastle upon Tyne.
Feb. 13.

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BIOCHEMISTRY

Production of Amide Groups and Ammonia in the Radiolysis of Aqueous Solutions of Protein

RECENT studies in this Laboratory have indicated[1,2] that a principal reaction in the radiolysis of aqueous solutions of protein under certain conditions involves cleavage of the peptide chain to form the carbonyl and amide functions as represented by the reaction :

$$\text{—CO—NH—CH}(R)\text{—} + O_2 + H_2O \rightsquigarrow \text{—CONH}_2 + R\text{CO—} + H_2O_2 \quad (1)$$

Evidence for this type of radiation-induced oxidation has been derived largely from studies of carbonyl production in oxygenated solutions of pepsin and gelatin. The carbonyl function is found to be associated with high molecular weight (non-dialysable) products which on conventional acid hydrolysis yield a series of α-keto acids. A correlation of these results in terms of a detailed mechanism for reaction (1) has been given elsewhere[2].

Substantiating evidence for the reaction as written has now been obtained from studies of the amide content of reaction products formed by γ-ray-induced oxidation of aqueous gelatin. Commercially available lime-process gelatin was found to be particularly suitable for this study since most of the amide groups of the glutamine and asparagine residues of the parent collagen are removed through hydrolysis during the manufacturing process[3]. Unmodified proteins, in general, contain amide groups in sufficient number to mask reaction (1) at the lower radiation dosages necessarily invoked in studies of initial reaction products.

Analyses were made for 'free' ammonia and for amide groups, both before and after irradiation. The stock solutions (3·5 per cent gelatin, purified calfskin, Eastman Lot 60-9680) had been previously dialysed to reduce the content of ammonia to a minimum value. Analytical procedures were, in brief, as follows : an appropriate aliquot of the solution was made alkaline to phenolphthalein and distilled at room temperature *in vacuo* into a receiver which contained 1 ml. of 0·1 *N* sulphuric acid at the temperature of liquid nitrogen. The distillate was isolated, thawed, and then assayed for ammonia by means of the Nessler reaction. A second aliquot of each solution was made 1 *N* in hydrochloric acid and heated for 1 hr. at 95° C. to liberate ammonia from amide linkages[4]. Subsequent treatment was then as described for ammonia. A series of control runs showed that the liberation of amide-ammonia was essentially quantitative under the mild hydrolysis conditions employed. Prolonged hydrolysis leads to the gradual breakdown of various labile amino-acids with the formation of what in this study would be 'artefact' ammonia[5,6]. An increase of 25 per cent in the number of amide groups in an irradiated solution as compared to the corresponding control solution could easily be observed with the method outlined above. Results shown in Table 1 were obtained on solutions that had been irradiated until the amide and ammonia content had reached values that were at least three times those of the control.

A 2,000-c. cobalt-60 γ-ray source was used in the irradiations. Solutions (10 ml.) were exposed under oxygen (5 ml.) at one atmosphere in sealed 'Pyrex' tubes. Contents were shaken at intervals to prevent depletion of oxygen in the solutions. The dose-rate was $2 \cdot 5 \times 10^{18}$ eV./ml./min.

Table 1. PRODUCTION OF AMIDE GROUPS AND AMMONIA IN THE γ-RAY RADIOLYSIS OF AQUEOUS GELATIN SOLUTIONS

	Yield (*G*)*	
	Series 1	Series 2
Amide groups	1·0 ± 0·1	0·9 ± 0·1
Ammonia	0·25 ± 0·05	0·30 ± 0·05

* Yield per 100 eV. absorbed energy

The results in Table 1 indicate that the formation of amide groups ($G \simeq 1$) corresponds to a principal reaction in the radiolysis of aqueous solutions of gelatin. Further, the *G* value for this product-group is very close to that obtained for total carbonyl formation under equivalent irradiation conditions[2]. The simplest explanation for these results would seem to involve the postulated reaction (1). Ammonia formation ($G \simeq 0 \cdot 3$) may be attributed to a radiation-induced oxidation of terminal and/or side-chain amino groups[7].

This work was performed under the auspices of the United States Atomic Energy Commission.

WINIFRED BENNETT
WARREN M. GARRISON

Crocker Laboratory,
Lawrence Radiation Laboratory,
Berkeley, California.
Jan. 8.

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Anion Inhibition of α-Glycerophosphate Dehydrogenase

RABBIT-muscle α-glycerophosphate dehydrogenase, which catalyses the reaction :

$$\text{dihydroxyacetone phosphate} + \text{DPNH} + \text{H}^+ \rightleftarrows \alpha\text{-glycerophosphate} + \text{DPN}$$

was first crystallized by Baranowski[1]. More recently, Beisenherz *et al.*[2] and Young and Pace[3] have reported work in which this enzyme was studied with respect to a number of physical and chemical properties. In all cases where the above reaction was studied by measuring the reduction of dihydroxyacetone phosphate, this substrate had been prepared enzymatically[4]. In connexion with work on the metabolism of acetol phosphate (monohydroxyacetone phosphate)[5], dihydroxyacetone phosphate was prepared by the procedure described by Ballou and Fischer[6] and it was used in the experiments reported here. It was observed that dialysis of solutions of α-glycerophosphate dehydrogenase—which contained ammonium sulphate during preparation by the published procedure[2]—resulted in an appreciable loss of activity in some fractions (details of these experiments will be published elsewhere). Activities were determined by the spectrophotometric method of Beisenherz *et al.*[2]. When ammonium sulphate was added back

Table 1. Effect of Salts on the Activity of Dialysed α-Glycerophosphate Dehydrogenase

Salt added*	Percentage inhibition
None	0
Ammonium sulphate	65
Potassium sulphate	65
Sodium sulphate	67
Ammonium chloride	60
Potassium chloride	54
Sodium chloride	45
Ammonium formate	21
Ammonium formate†	40
Sodium formate	12
Sodium formate†	44
Ammonium sulphite	88
Sodium sulphite	85

For the measurement of the enzymatic activity, △ optical density (340 mμ) per 40 sec., the reaction mixture contained, in 3·0 ml. of total volume, dihydroxyacetone phosphate (1×10^{-4} *M*), reduced diphosphopyridine nucleotide (about $1·5 \times 10^{-4}$ *M*), *tris*(hydroxymethyl) aminomethane buffer, *p*H 7·7 (4×10^{-2} *M*), α-glycerophosphate dehydrogenase (53 μgm., specific activity, 180), which was dialysed for 24 hr., and the salts listed below, to give the ionic strength indicated. In the control cuvette, reduced diphosphopyridine nucleotide was replaced by an equal volume of distilled water

* The ionic strength due to the addition of the salt was 0·19.

† Ionic strength was 0·57.

to the previously dialysed enzyme, a strong diminution of activity was noted as compared to activity of dialysed enzyme to which no ammonium sulphate was added. It was established, by comparing the effect of the corresponding sodium and potassium salts on the enzymatic activity, that this inhibitory effect was due to the anionic portion of the ammonium sulphate molecule. In addition, the ammonium, sodium and potassium salts of hydrochloric acid and the ammonium and sodium salts of formic and sulphurous acids were tested for an inhibitory effect.

Table 1 shows that, at an ionic strength of 0·19, *p*H 7·7, 24° C., the percentage inhibition of the enzymatic activity was a function of the particular anion tested. It can be seen also that an increase in ionic strength resulted in an enhancement of the observed inhibition in the case of formate. The influence of some sodium salts of different anions on the activity of α-glycerophosphate dehydrgoenase was then studied, and it was noted that, with the exception of glycine and ethylenediamine tetraacetate, all the anions tested exhibited inhibitory properties (Table 2). The ability of sulphite to inhibit α-glycerophosphate dehydrogenase was recently reported by Pfleiderer *et al.*[7], who observed that 20–50 μgm. of sulphite caused 25 per cent inhibition. The present results, in which 30 μgm. of sulphite ($3·8 \times 10^{-4}$ *M*, Table 2) were shown to inhibit the dialysed enzyme by 17 per cent, are in good agreement with the findings of Pfleiderer *et al.*[7], who used undialysed enzyme preparations. It is of interest to note that the failure of glycine and ethylenediamine tetraacetate to inhibit α-glycerophosphate dehydrogenase, under the experimental conditions employed, bears resemblance to the results obtained by Theorell *et al.*[8] with liver alcohol dehydrogenase.

Table 2. Effect of Anions on the Activity of Dialysed α-Glycerophosphate Dehydrogenase

Anion	Final concentration of added salt (*M*)	Percentage inhibition
None	—	0
Acetate	$1·9 \times 10^{-1}$	38
Bicarbonate	$1·9 \times 10^{-1}$	65
Glycine	$1·9 \times 10^{-1}$	0
Bromide	$2·3 \times 10^{-1}$	55
Nitrate	$2·3 \times 10^{-1}$	59
Azide	$5·0 \times 10^{-6}$	14
Azide	$5·0 \times 10^{-4}$	18
Azide	$5·0 \times 10^{-2}$	22
Sulphite	$3·8 \times 10^{-4}$	17
Sulphite	$3·8 \times 10^{-3}$	33
Sulphite	$3·8 \times 10^{-2}$	78
Sulphite	$6·3 \times 10^{-2}$	85
Sulphate	$6·3 \times 10^{-1}$	95
Phosphate	$4·7 \times 10^{-2}$	52
Ethylenediamine tetraacetate	$1·1 \times 10^{-2}$	0

The assay system, as described in Table 1, was used. The sodium salt solutions were adjusted to *p*H 7·5–7·9 prior to their addition to the cuvette

The observed high sensitivity of the dialysed α-glycerophosphate dehydrogenase to sulphate, an anion to which the enzyme is entirely stable prior to dialysis, may be tentatively explained by assuming that the prolonged dialysis causes the rupture of the bond between the nucleotide and the enzyme to which the nucleotide is known to be intimately bound[1,2]. This results in the exposure of active sites on the enzyme surface with a high but rather non-specific sensitivity to anions.

This work was supported by the Division of Grants and Fellowships, National Institutes of Health, U.S. Public Health Grant No. *H*-1525. The results were taken from a thesis submitted by Otto Z. Sellinger to the Graduate School of Tulane University in partial fulfilment of the requirements for the degree of doctor of philosophy.

Otto Z. Sellinger*
O. Neal Miller

Department of Biochemistry and the
Nutrition and Metabolism Research Laboratory
of the Department of Medicine,
Tulane University School of Medicine,
New Orleans.

* Present address: Department of Physiological Chemistry, University of Louvain.

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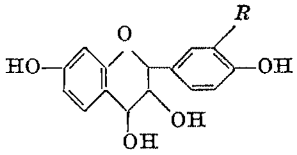
Flavan-3.4-diols and Leuco-anthocyanidins of *Guibourtia* spp.

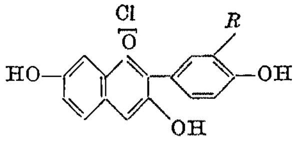
Probably the most interesting of the large number of heartwood specimens previously examined[1] on two-way paper chromatograms by the toluene-*p*-sulphonic acid reagent[1,2] are the extractives of some of the species of the genus *Guibourtia*, previously known as *Copaifera*. Those extractives of *Guibourtia coleosperma*, *G. tessmannii* and *G. demeusei* which are soluble in methanol, for example, redden rapidly on exposure to direct sunlight and furnish high yields of anthocyanidins when treated with 3 *N* hydrochloric acid/propan-2-ol (1 : 5) under pressure[3] (about 8 per cent yield) or under anhydrous conditions with *N*/40 hydrochloric acid[4] (about 13 per cent yield). These extractives may be fractionated into a high proportion of tannins insoluble in water and with an average molecular weight of about 2,200, and a low proportion of polyphenols and carbohydrates soluble in water. Examination of the latter fraction with the toluene-*p*-sulphonic acid spraying reagent on two-way paper chromatograms shows the probable presence of flavan-3.4-diols with R_F values corresponding to 0·45–0·55 in 2 per cent acetic acid (second irrigant), but with differing R_F values in the partitioning mixture used (butan-2-ol saturated with water : first irrigant)[5].

Two such compounds have been isolated in low yield, and were examined more closely as they appear to be directly related to the constitution of the highly condensed tannins present. Component I (R_F = 0·54 and 0·59 respectively) gives the same colour reactions and runs to the same position on two-way chromatograms as (+)-7.3′.4′-trihydroxyflavan-3.4-diol (mollisacacidin[6] and gleditsin[7]). Heating with alcoholic hydrochloric acid[3] affords a pink anthocyanidin, fisetinidin chloride (compound III, R = OH), and the compound undoubtedly is a 'leuco-fisetinidin' of structure I (R = OH).

Component II (R_F = 0·53 and 0·78 respectively) shows very weak reducing properties towards ammoniacal silver nitrate in the cold and its chromatographic behaviour in the partitioning mixture (R_F = 0·78) suggests that it has one hydroxyl group less than the accompanying 'leuco-fisetinidin' (R_F = 0·59)[8]. Furthermore, the weak reducing properties of II compared with I suggest that the new compound contains no vicinal hydroxyl groups on the *B* ring. Most significant, however, is its conversion in about 20 per cent yield into the yellow anthocyanidin, 3.7.4′-trihydroxyflavylium chloride[9] (compound IV, R = H) ($\lambda_{max.}$ = 490 mμ and R_F 0·60 in 3 *N* hydrochloric acid/90 per cent formic acid (1 : 1)). This and other evidence suggest that the compound has the structure 7.4′-dihydroxyflavan-3.4-diol (component II, R = H). This substance therefore appears to be the third member of the series of flavan-3.4-diols containing resorcinol, for example, leuco-robinetinidin[10], leuco-fisetinidin[6,11] and 7.4′-dihydroxyflavan-3.4-diol. The trivial names guibourtacacidin and guibourtinidin are proposed for the new leuco-anthocyanidin (component II, R = H) and for the anthocyanidin (compound IV, R = H)[9] generated from II respectively.



I, R = OH
II, R = H



III, R = OH
IV, R = H

Significance is attached to the observation that where these flavan-3.4-diols are present in *Guibourtia* species, the high molecular weight tannins which accompany them furnish high yields of both fisetinidin and guibourtinidin chlorides.

Further work on these compounds is in progress and will be published elsewhere.

D. G. Roux
Leather Industries Research Institute,
Rhodes University,
Grahamstown. Nov. 6.

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ANIMAL PHYSIOLOGY

Chlorothiazid in Diabetes Insipidus

Laragh and his co-workers[1] have demonstrated that chlorothiazid administered to normal subjects in the midst of a sustained water diuresis provokes a flow of urine of substantially higher concentration for a given rate of total osmolar output than urine formed by water-loaded subjects to whom meralluride is given. On the basis of this finding, they suggested that the site of action of chlorothiazid was in the distal portion of the nephron. Here, they postulated that the drug inhibited the production of 'free water' which normally results from selective re-absorption of sodium and accompanying anions. A drug acting to interfere with free-water formation would be of therapeutic value to the patient with diabetes insipidus, particularly the nephrogenic sort, if attendant losses of electrolyte in the urine were not unduly large, or, indeed, should they fail to occur.

Much more severe and sustained diabetes insipidus can be induced in the rat by electrolytic damage to the hypothalamus[2] than by the more usual technique of surgical removal of the posterior lobe of the pituitary gland. The technique consists of complete, or almost complete, destruction of the connexions in the anterior hypothalamus between the supra-optic nucleus and the pituitary stalk. The tracts concerned are difficult to identify in the rat[3] but are probably diffuse. The best combination of high survival-rate with severe diabetes insipidus is obtained by introducing stereotaxically two contiguous pairs of lesions at separate operations, allowing a recovery interval of 7–10 days. An initial pair of bilateral lesions gives rise to a mild diabetes insipidus characterized by water requirement ranging from just above normal (about 20 ml./250 gm. rat) to as much as 100 ml. a day when the adult animals consume quantitatively 20 gm. of diet 41 described by Bruce and Parkes[4]. The more severely affected animals are selected and respond to a second, similar operation by a marked increase in polyuria. On the same, 20 gm. diet allotment intakes of water following this procedure may exceed 400 ml. a day or almost twice the body-weight of the animal. The doubly operated animals fail to reduce the rate of flow of their urine in response to nicotine, hypertonic saline injection or 2-phenyl, 3-hydroxycinchoninic acid[5]. Sustained water-loading does not provoke flows of urine significantly in excess of those seen during *ad libitum* drinking, and water restriction results in marked dehydration, food refusal and loss of body-weight.

Chlorothiazid has been administered to animals with this form of severe diabetes insipidus by admixture with the daily food ration. They respond within 24 hr. by reduction of intake of water by 50 per cent or more as indicated in Fig. 1. Urine osmolality rises from hypotonic levels to approach and, in some instances, to exceed by a small margin the tonicity of plasma. Urine *p*H is essentially unchanged, and the animals show no tendency to lose weight. The effect of the drug is sustained over long periods of time but disappears promptly on cessation of treatment. No influence on water turn-over is seen in similarly treated control animals. Nevertheless, in animals with submaximal diabetes insipidus, however mild, chlorothiazid causes the same proportionate reduction of water turn-over as it does in the more severe cases. Doses of 80 mgm./kgm. body-weight give a detectable effect ; maximal response is seen at dose-levels of 300 mgm. a day and twice this dose has been reported to be well tolerated in normal rats for as long as six months[6].

The effect described for the rat is not species specific but has been reproduced in two human subjects, one with diabetes insipidus due to lack of vasopressin, the other with the nephrogenic type which is insensitive to the hormone. Within an hour of initial chlorothiazid administration there may occur an increase in urinary sodium, chloride and potassium excretion rates as well as a rise in urine osmolality. Urinary *p*H is not appreciably influenced. The solute diuresis is of brief duration ; but the elevation in osmolality persists and within 6 hr. volume of urine begins to fall. The response of one patient in terms of the changes in urine volume and osmolality calculated on a 24-hr. basis is shown in Fig. 2. It will be noted also that though the dose requirement of the rat appears large, responses in the human are obtained at the same dose-levels as are employed when the drug is used as a diuretic. Clinical trials are being continued and will be reported elsewhere.

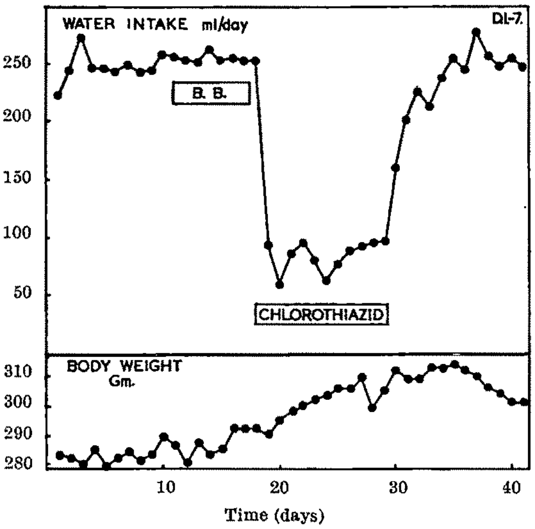

Fig. 1. Influence of chlorothiazid, 300 mgm./kgm. a day, on spontaneous water intake and body-weight of a rat with diabetes insipidus. The failure of di-*n*-butylamido-*p*-carboxybenzenesulphonate (50 mgm./kgm. a day) to influence either of these variables is shown by the block labelled *B.B.*

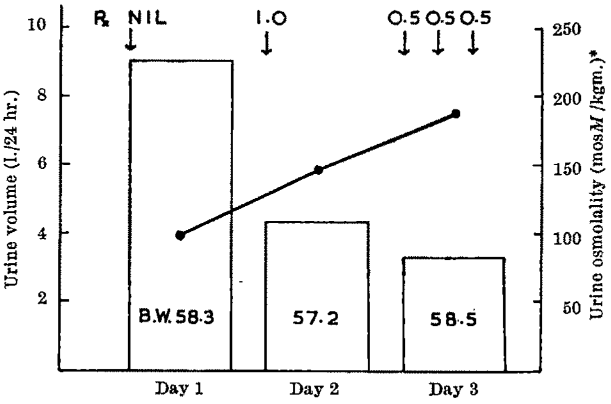

Fig. 2. Influence on urine volume (columns) and osmolality (interconnected points) of chlorothiazid in a woman with vasopressin insufficiency diabetes insipidus of three years duration. Day 1 represents a control 24-hr. period during which no treatment was given. A single 1-gm. dose was given at the start of day 2. On day 3, doses of 0·5 gm. were administered at 8-hourly intervals. Water to drink was allowed *ad lib.* and the diet was essentially constant throughout. Body-weights are given by the figures in the lower portions of the columns

Mrs. O. S. (46 yr.)

* This figure denotes total effective osmolal concentration of the urine in milliosmoles per kilogram of water found by determination of the urine's freezing point depression and division of the latter figure in deg. C. by the constant, 1·86.

The mechanism of action of the drug remains obscure. Treatment of the diabetic animals with heavy doses (100 mgm./kgm. a day) of the much more potent carbonic anhydrase inhibitor, acetazoleamide, results in no appreciable antidiuresis. Moreover, far more active inhibitors of tubular transport of *p*-amino-hippurate, phenol red and penicillin such as probenecid and its di-butyl analogue, which have been reported by Bachman[7] and Polster[8] to lessen the water turn-over in human diabetes insipidus, are similarly ineffective. Although the mechanism proposed by Laragh[1] may be invoked to explain the initial effect, its acceptance requires that one must postulate in addition a prompt, secondary adjustment leading to re-absorption of electrolytes at some site other than the point of free-water formation, since long-term therapy is well tolerated by the animals. Studies designed to clarify the mechanism by which the drug acts are in progress.

J. D. Crawford
G. C. Kennedy

Department of Experimental Medicine,
Cambridge.
Jan. 26.

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Changes in the Group *A* Antigen in a Case of Leukæmia

Van Loghem and his colleagues[1] and Stratton *et al.*[2] have each reported a case in which a patient's group *A* antigen became weakened during the course of an illness. Salmon *et al.*[3] observed a similar case in which the red cells showed a 'double-cell population'. We have had the opportunity to observe a further example of weakening of the A antigen, with double-cell population, and, in addition, a partial reversion towards normal during a temporary clinical remission.

A male patient aged nineteen years was admitted to hospital because of acute monoblastic leukæmia. In routine blood grouping tests for a transfusion his red cells were very weakly agglutinated by the anti-A grouping serum. Anti-B agglutinins were present in his serum in normal titre. A differential agglutination test showed that approximately 2 per cent of the cells were agglutinated by potent anti-A sera; but the remainder, although inagglutinable, absorbed anti-A to the same extent as A_2 cells. This anti-A could readily be eluted by the heat-method. 3 days later, the red cells in a fresh sample were no longer agglutinable, even by selected group O 'immune' anti-A sera, but continued to absorb anti-A. At this time, the total white cell count was 118,000 per cu. mm., of which approximately 90,000 were 'blast' cells.

After treatment for 8 weeks with 6-mercaptopurine and prednisone, the total leucocyte count had fallen to 2,300 per cu. mm., a very occasional blast cell only being present in the peripheral blood and the bone marrow. To our surprise, approximately 35 per cent of red cells were now agglutinated by anti-A sera (group B). There was no agglutination by Dolichos anti-A_1, the agglutinable cells appearing to behave, therefore, as normal A_2 cells. The unagglutinated cells, separated by differential agglutination, continued to absorb anti-A.

The partial reversion towards normal which accompanied the hæmatological remission was also paralleled by a clinical remission. The 6-mercaptopurine was discontinued and 7 weeks later, when the total leucocyte count had risen to 7,900 per cu. mm. (blast cells, 790), the percentage of agglutinable A cells had fallen to 20 per cent. The clinical remission terminated abruptly 4 weeks later and just before death, with a blast cell count of 23,600 per cu. mm. (total leucocytes 62,000); 8 per cent only of red cells in peripheral blood and marrow were now agglutinable.

During the period of observation, there was no change in the patient's anti-B agglutinins and no irregular anti-A antibodies could be demonstrated *in vitro*. *In vivo*, however, 1 ml. of group A_1 red cells labelled with chromium-51 survived for a much shorter time than similarly labelled group O cells. When transfusion was necessary, therefore, group O packed cells were selected in preference to group A. Unfortunately, circumstances prevented a repeat injection of labelled group A and O cells, and we were unable to establish definitely, therefore, that the blood-group change was accompanied by an unexpected intolerance to small amounts of group A_1 blood. No group A substance was found in the serum or saliva, even using a group O anti-A serum which agglutinated A_x cells. Tests of the two types of red cells present, after separation, for other blood group antigens (M,N,S, P, H, Le^a, C,D,E,c,e, Jk^a, *Kell*, Fy^a) showed no differences, except that, whereas both types of red cells were agglutinated by anti-H (*Ulex*) and anti-Le^a, the cells inagglutinable by anti-A reacted considerably more strongly with the anti-H but slightly less strongly with the anti-Le^a than did those agglutinable by anti-A.

It is interesting to note that in this case, as in those reported by Van Loghem and his colleagues, and by Stratton *et al.*, the red cells were Le^a-positive and the patient was a non-secretor of A and H substance. These three antigens are chemically related, and in the four cases now on record in which the A antigen has been modified by disease, the patient's underlying illness was leukæmia. The case reported by Stratton *et al.* presented as a hypoplastic anæmia, but terminated as a leukæmia (Stratton, F., personal communication, 1959). Our case was established as a monocytic leukæmia and remained as such throughout its course. No explanation can yet be given concerning the mechanism of the changes in blood group, though Haddow's[4] hypothesis of genetic and enzymatic deletion in neoplasias, including leukæmia, by physical, chemical or viral agents might provide an explanation for a similar action on genes governing the formation of the A, H and Le^a antigens.

The patient's blood group was not known prior to his illness. His mother is A_1 and his father O. Family studies have failed to demonstrate the mother's genotype; but the patient's only brother and his three maternal aunts and uncles are A_1 or A_1B. By inference, therefore, it is more likely that the patient's group was A_1 rather than A_2. It is most unlikely that it was A_x, since the agglutinable cell population behaved as normal A_2 cells.

We wish to thank Dr. G. Mather for the opportunity to investigate this patient, and Drs. N. F. W. Brueton and F. Freundlich for their assistance in the investigations.

E. R. GOLD
GEOFFREY H. TOVEY
South-West Regional Transfusion Centre.
W. E. BENNEY
F. J. W. LEWIS
Department of Pathology,
Southmead Hospital,
Bristol. Jan. 6.

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Absorption of Radioiodine through the Bladder-Wall in the Rabbit

NUMEROUS studies have been made of the absorption of a variety of substances through the bladder-wall in frogs, rabbits, canines and humans[1-8]. We report below a study of some factors influencing the absorption of iodide ions in rabbits.

Male rabbits weighing 2–3·5 kgm. were used, and experiments were carried out under urethane anæsthesia. The rabbits were catheterized with Nélaton catheters (diam. 12–13 Charrière), and urine samples were shown to be free of hæmoglobin. After irrigation of the bladder with isotonic saline, radioiodine or a compound of it was introduced into the bladder. Blood samples were collected after 0, 20, 40, 60 and 80 min. from the marginal ear vein. Beta-activity of the samples was measured with a Geiger–Müller counter.

(1) In 3 animals 10–20 ml. isotonic saline containing 0·36–2·0 mc. of sodium iodide labelled with iodine-131 was left in the bladder for 45 min. After 24 hr. the thyroid glands showed activities of 7–23 μc. Approximate determinations of gland activities were carried out on a phantom with the help of a scintillation counter. The results demonstrate absorption of radioiodine through the bladder-wall.

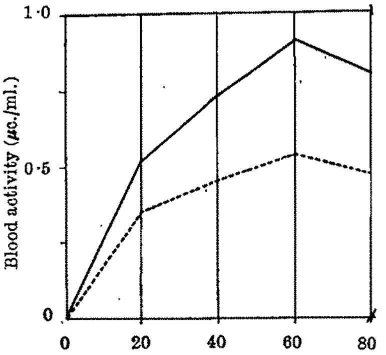

Fig. 1. ———, 1·2 osmolar sodium iodide solution; – – – –, 30 milliosmolar sodium iodide solution

(2) In 4 rabbits 5 ml. isotonic saline containing 20 mgm. radioiodinated human serum albumin with an activity of 700 μc. was introduced into the bladder and left for 60 min. In two animals 1 mgm. hyaluronidase was added to the solution. Whole samples were rendered free from protein with 15 per cent trichloracetic acid. Measurements made on the filtrate and on the precipitate did not show significantly higher values than in group 1. These results indicate that molecules of the size of serum albumin are relatively unabsorbed through the bladder-wall.

(3) In 3 rabbits 1 mgm. adrenaline was introduced along with 5 ml. isotonic saline containing 1 mc. radioiodine. No significant differences were found in comparison with 3 controls. This showed that the addition of adrenaline did not alter in any significant way the absorption of radioiodine under the experimental conditions described.

(4) In 9 rabbits 5 ml. of a 30 milliosmolar non-radioactive sodium iodide solution was used, and in a further 9 animals a 1·2 osmolar sodium iodide solution was applied, 1 mc. of labelled sodium iodide being added to each solution. The activities of blood samples were higher in all animals receiving the hypertonic solution. Mean activity curves of both groups are shown in Fig. 1. The results show a dependence of absorption on concentration gradient.

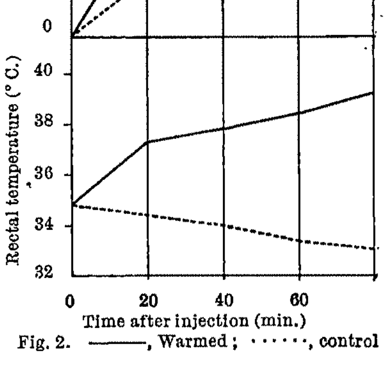

Fig. 2. ———, Warmed; ······, control

(5) In 8 rabbits 5 ml. of 0·3 osmolar sodium iodide with activity of 1 mc. was introduced into the bladder. In 5 animals the lower part of the body was heated by short-wave diathermy or by infra-red rays. The average rise of rectal temperature amounted to 4° C. after 60 min. Curves of mean blood activity and rectal temperature of both groups are shown in Fig. 2. These findings demonstrate a dependence of absorption on the rectal temperature and therefore on the rate of blood supply to the bladder-wall.

We conclude that significant re-absorption of urinary iodide occurs through the bladder-wall and suggest that local bladder conditions should be taken into account in quantitative physiological studies with this ion.

OSKAR ANDRYSEK
OTA SCHÜCK

Institute for Medical Physics and
First Medical Clinic,
Charles University, Prague.

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Disturbance in the Pattern of Serum Proteins in Experimental Atherosclerosis and its Prevention

IT has recently been reported by two of us[1,2] that various kinds of experimental atherosclerosis, indicated by great increase in the total cholesterol/lipid phosphorus ratio in the blood and tissues of animals, can be prevented by hydrolysed glucose–*cyclo*acetoacetate, a product formed by condensing glucose with acetoacetate. It was shown by Van Dommeleu and Schutt[3] that albumin fraction is low and γ-globulin is high in diabetic coma, and Klinger[4] observed that when diabetes is accompanied with severe hypertension, there is a further decrease of albumin and a sharp increase of γ-globulin. As according to Dawber *et al.*[5] hypertension is usually associated with the incidence of atherosclerosis, attempts were made to study the protein pattern in the serum of saturated fat-induced atherosclerotic animals and in those prevented by essential fatty acids, inositol, vitamin B_{12} and glucose–*cyclo*acetoacetate (hydrolysed).

Thirty-five male albino rabbits weighing on an average 1·2 kgm. were divided into seven equal groups and caged individually. The animals of group 1 were fed with a laboratory stock diet consisting of casein 20 gm., sucrose 30 gm., wheat flour 39 gm. groundnut oil 6 gm., Hawk Oser salt mixture 5 gm. and all the vitamins of B complex group and vitamins A and D in requisite quantities. The animals of all the remaining groups were given saturated fat (20 per cent of the diet) in place of groundnut oil. The animals of group II were taken as control while those of groups III and VI were injected with a daily dose of 300 mgm./kgm. and 1·5 μgm./kgm. body-weight of glucose–*cyclo*acetoacetate (hydrolysed) and vitamin B_{12} ('Macrabine', Glaxo) respectively, and those of groups IV, V and VII were given 1 gm. of linoleic, linolenic acid and inositol respectively along with the saturated fat diet.

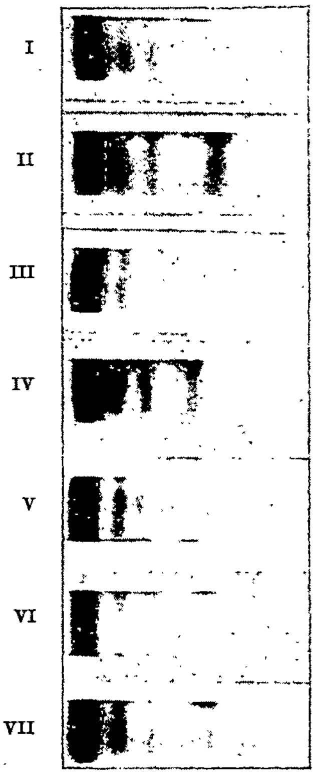

Fig. 1. Agar electrophoresis patterns of serum proteins of normal, saturated fat-induced atherosclerotic and treated animals. (I) Normal; (II) saturated fat-induced; (III) kept on saturated fat and injected with glucose-*cyclo*acetoacetate (hydrolysed); (IV) linoleic acid supplemented; (V) linolenic acid supplemented; (VI) kept on saturated fat and vitamin B_{12} injected; (VII) inositol supplemented

The experiment was carried on for a period of 12 weeks. The blood samples were drawn from the marginal ear veins of the rabbits, and the serum obtained by the usual method was used for electrophoretic studies.

The agar electrophoresis technique developed by Giri[6] was employed for the separation and staining of serum proteins, amidoschwarz 10*B* in 100 ml. of solvent mixture of the composition methanol/acetic acid/water (40 : 10 : 50) being used for staining.

Albumin, α-, β- and γ-globulins in the serum were found to be clearly separated on the agar plate. Photographs of the serum patterns of the rabbits of normal and experimental groups are shown in Fig. 1. The electrophoresis of serum samples was run under exactly identical conditions. From pattern II, it is evident that the γ-globulin fraction of the rabbits kept on high saturated fat diet increased appreciably with a simultaneous decrease in the albumin fraction as compared to pattern I of normal rabbits. On the other hand, in the patterns IV (linoleic acid supplemented), V (linolenic acid supplemented) and VII (inositol supplemented), it has been observed that the γ-globulin fractions, although found to be less than that in pattern II (kept on saturated fat diet), the amount was not as low as in normal animals. It is further observed from pattern IV that the effect of linoleic acid in suppressing the rise of γ-globulin fraction was not so pronounced as in the case of linolenic acid and inositol (patterns V and VII respectively). The serum pattern of animals injected with vitamin B_{12} (pattern VI) was found to show a greater decrease in γ-globulin fraction and increase in albumin fraction than those of patterns IV, V and VII; but still the pattern was not normal. However, the serum protein pattern III of rabbits injected with hydrolysed glucose-*cyclo*-acetoacetate is found to be very similar to the normal pattern I.

From the above findings, the γ-globulin fraction has been increased in the animals with atherosclerosis induced by a saturated fat diet that could be corrected by glucose–*cyclo*acetoacetate (hydrolysed), which has already been shown to contain 1 : 2 dienol glucose[7] and to cause prevention of experimental diabetes of various kinds[8-10]. It has recently been suggested by Beveridge *et al.*[11] that the serum cholesterol lowering effect of corn oil is due to something besides the unsaturated fatty acid glycerides of the corn oil, and Grande *et al.*[12] have shown that such a factor (*X*) is present in the unsaponifiable fraction of corn oil. It is quite possible that such *X* factor may be in some way or the other related to glucose–*cyclo*acetoacetate or its hydrolysed product.

M. C. Nath
A. Saikia
B. I. Uppin

Department of Biochemistry,
University, Nagpur.
Nov. 1.

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Study of Adenovirus Antigens by Immunoelectrophoresis

Multiplication of adenoviruses in susceptible cells is accompanied by the formation of antigenic materials which can be distinguished from virus particles. These materials have been detected by different serological techniques including complement fixation[1,2], sensitized red-cell agglutination[3], conglutinating complement adsorption[4] and gel diffusion precipitation[5]. Part of the non-virus material is responsible for the early cytopathic[6] and cell-detaching[7] properties which are abolished by incubation with trypsin or by addition of homologous antiserum, a result suggesting that they are mediated by an antigenically specific protein.

Observations with the gel diffusion precipitation technique have shown at least three antigens in partially purified preparations of adenovirus type 5. The conditions under which precipitation occurs make it clear that these antigens are considerably smaller than intact virus particles[8]. Results of experiments in which the three precipitating antigens were separated by electrophoresis are presented in this communication.

The virus material used consisted of the prototype strain of adenovirus type 5 propagated in HeLa cells

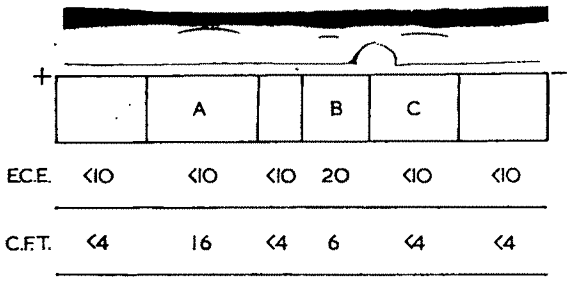

Fig. 1. Immunoelectrophoresis of adenovirus type 5 antigen tested against homologous antiserum. Top, photographic print of precipitation lines; bottom, early cytopathic effect (E.C.E.) and complement-fixing titres (C.F.T.) of extracts from agar sections

and partially purified by the method of Gessler *et al.*[9] using the fluorocarbon compound 'Arcton 63' as previously described[10]. Adenovirus type 5 antiserum was obtained from a rabbit with a latent infection[11]. The serum reacted strongly with the virus antigen in complement fixation and gel diffusion precipitation tests, while no reactions with normal HeLa cell antigens could be demonstrated by either technique.

Immunoelectrophoresis[12] was performed in a gel[8] composed of 2 per cent washed agar in borate–phosphate buffer (μ = 0·05 *p*H 8·5)[13]. The same buffer was present in the electrode baths and on the lint connecting strips. Electrophoresis of 0·1-ml. samples of the antigen was conducted at room temperature with a current of 20 m.amp. for 7–8 hr. Antiserum placed in pre-formed side channels was allowed to react with the antigenic material at 4° C. in a moist chamber. After 5–6 days the gel was washed in saline, dried, stained with naphthalene black and made into a permanent preparation.

Three antigens with different electrophoretic mobilities could be demonstrated (Fig. 1). These will be designated antigens *A*, *B* and *C*. In order to characterize the antigens they were eluted from the agar. After electrophoresis the agar was cut in half by an incision through the origin along the plane of migration. One half was treated with antiserum to show the position of the antigenic components. The other half was cut into sections according to the expected position of the antigens. Each section was cut into small pieces and suspended in 1 ml. of normal saline at 4° C. for 4 days. The saline extracts were then tested for complement fixation against an optimal dilution of homologous antiserum and for early cytopathic action on HeLa cells, the results being read after overnight incubation of the cultures[6], Complement-fixing activity was detected in fractions corresponding to antigens *A* and *B*. The titres obtained were relatively low, suggesting poor recovery, which may explain the negative result given by the third antigenic component.

Early cytopathic activity was associated with antigen *B* only, although the complement-fixing activity of this component was less than that of component *A*. Further evidence that antigen *B* is responsible for the early cytopathic action is provided by the effects of trypsin treatment of the virus material. This abolishes the early cytopathic effect[6] and brings about only a slight reduction in complement-fixing titre[8]. When immunoelectrophoresis is carried out on trypsin-treated material, components *A* and *C* are unaffected but component *B* is no longer demonstrable.

The relationship of these antigenic components to non-viral crystalline material appearing in ultra-thin sections of adenovirus-infected cells[14] remains to be established.

H. G. PEREIRA
A. C. ALLISON
C. P. FARTHING

National Institute for Medical Research,
Mill Hill, London, N.W.7.

Jan. 6.

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Effect of Tranquillizing Agents on the Resistance of Rats to Histamine Stress

IN view of the long-continued interest in the relationship of histamine to metabolic processes and disorders, most particularly allergy and psychosis, the present investigation sought to explore the effects of prolonged administration of various tranquillizers on response in the rat to histamine, including effects on such variables as histamine *LD*50, mortality and alterations in body-weight.

Male albino Wistar rats (80–90 per test group), averaging 100 gm., were injected subcutaneously with 1 ml. aqueous preparations of different tranquillizers daily for a two-week period. Control rats received 1 ml. daily injections of distilled water. On the fifteenth day, test and control groups were injected intraperitoneally with various amounts of histamine phosphate. The challenging doses ranged from 300 to 1,100 mgm./kgm. body-weight. Finney's[1] method of probit analysis was used for calculating the *LD*50 values and dose–response lines.

Table 1 presents the various tranquillizing agents studied, their concentrations and the histamine *LD*50, body-weight and mortality-rate results. The study indicated that hydroxyzine hydrochloride, reserpine and promazine hydrochloride are effective in preventing death from histamine shock, whereas azacyclonal hydrochloride has an intermediate effect and chlorpromazine hydrochloride a negligible influence.

Statistical analyses of the results for histamine *LD*50 revealed that hydroxyzine hydrochloride and promazine hydrochloride produce significant increases in resistance of the rat to histamine and the increase produced by reserpine approached statistical significance at the 0·05 confidence-level. Additional calculations revealed that none of the differences between the slopes of the various test and control dose–response lines were statistically significant.

As is apparent in Table 1, all tranquillizing agents studied caused significant declines in the terminal

Table 1. Effect of Tranquillizing Agents on Mortality-Rates, Body-weight and *LD*50 Values

Agent	Concentration (mgm./ml.)	Tranquillizer mortality (per cent)	Terminal body-weight	Difference between test and control (per cent)	*P* value	*LD*50 (mgm./kgm.)	Difference between test and control (per cent)	*P* value
Control	1 ml. distilled water	0	168·7 ± 1·3			599·3 ± 40·2		
Chlorpromazine hydrochloride	0·1	3·3	151·3 ± 2·6	−10·3	< 0·001*	606·4 ± 48·1	± 1·2	0·88
Azacyclonal hydrochloride	1·0	0	159·9 ± 2·2	−5·2	0·05*	665·3 ± 51·0	± 11·0	0·20
Promazine hydrochloride	0·1	12·5*	152·8 ± 0·7	−9·4	< 0·01*	700·4 ± 39·8	± 16·9	0·03*
Reserpine	0·007	26·7*	145·7 ± 2·9	−13·6	< 0·001*	699·3 ± 53·3	± 16·7	0·08
Hydroxyzine hydrochloride	0·07	18·9*	135·7 ± 3·1	−19·6	< 0·001*	816·6 ± 35·5	± 36·3	0·001*

* Difference between test group and control is significant.

body-weights of the treated rats in the dosages and time patterning of these experiments. Prior to histamine administration, all tranquillizers except azacyclonal hydrochloride and chlorpromazine hydrochloride caused significant increases in the mortality-rates of the rats during the two-week period. A preliminary study with reserpine concentrations of 0·1 mgm./ml. had to be discontinued after 7 days due to the excessive mortality-rate. Although Gaunt *et al.*[2] do not indicate the mortality-rates caused by various reserpine concentrations, they do state : "In work with normal rats, we found that 10 mcgm./100 gm./day of reserpine was not well tolerated when given for prolonged periods of time. It interfered with growth, appetite, etc., and we considered it unsuitable for chronic use".

In conclusion, hydroxyzine hydrochloride, reserpine and promazine hydrochloride when administered for two weeks caused marked increases in resistance to histamine as measured by histamine *LD*50. Except for azacyclonal hydrochloride, increase in resistance to histamine was associated with loss in body-weight and increase in pre-histamine administration mortality.

ARTHUR M. SACKLER
A. S. WELTMAN
RAYMOND R. SACKLER

Laboratories for Therapeutic Research,
Research Institute of the Brooklyn College
of Pharmacy,
Long Island University, Brooklyn,
New York, and
The van Ophuijsen Center, New York.

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Slow Contraction of Smooth Muscle produced by Human Plasma

HUMAN blood plasma or serum produces a delayed, slow contraction of the isolated ileum of the guinea pig. This effect is best observed with dialysed plasma, since dialysis eliminates the quick-contracting agents[1]. Recently, Gabr[2] described the isolation from the *G*.2 fraction of human plasma[3] of a fatty acid which has an effect similar to that of plasma on the isolated ileum of the guinea pig.

Preliminary experiments carried out on processed human plasma for transfusion purposes showed that storage at room temperature of liquid plasma[4] changes the character and potency of its contracting effect on the isolated ileum. It has also been observed that processing of the plasma with kaolin[5] and pooling of the plasma derived from stored banked blood produce similar changes. These observations may be summarized as follows :

(1) Storage of liquid plasma at room temperature under sterile conditions for six months decreases its toxicity for the isolated ileum of the guinea pig. The muscle contraction starts more slowly, and the recovery of the smooth muscle takes a longer time after repeated washings of the preparation with the test fluid (Tyrode solution).

(2) Processing of human plasma with kaolin considerably decreases its effect on the isolated ileum. Like normal plasma, kaolin-processed plasma becomes less toxic when stored for six months at room temperature.

(3) Pooled human plasma is less active on the isolated ileum than single-donor plasma. This effect seems to depend on the size of the plasma pool. Plasma pools derived from ten bottles of banked blood were found to be less active on the isolated ileum than plasma pools derived from seven bottles of banked blood. Again, the latter pools were less active than smaller pools derived from three blood bottles. In the case of big plasma pools, the onset of muscle contraction was much slower, and the summit of contraction often declined a few seconds after.

(4) No relation could be found between the toxicity of pooled plasma and the group types of the blood bottles from which the plasma was separated.

(5) The effect of pooled plasma on the isolated ileum of the guinea pig decreases slightly after standing for one week at room temperature prior to freeze-drying.

YOUSRY GABR
RAGA H. ALY

Blood Products Unit,
Serum and Vaccine Institute,
Agouza, Cairo.

Jan. 14.

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Barbiturate Nystagmus and the Mechanisms of Visual Fixation

WHEN a human subject follows a moving object with his eyes, they perform movements of two types[1,2]. There are smooth pursuing movements and rapid jerky changes of position known as saccades. Fig. 1*a* is a record of the position of an eye which is fixating a small spot of light in an otherwise totally dark room. Up to time $t = 0$ this spot of light has remained stationary in front of the subject. At time $t = 0$ it begins to move horizontally with a uniform velocity of 3 deg./sec. It can be seen that the eye remains stationary for about 150 msec., and then begins to move smoothly in pursuit of the spot. When about 300 msec. has elapsed since the spot began to move, the eye makes a saccadic movement at the end of which it is again looking directly at the spot. Thereafter the eye continues to move with the same velocity as the spot, and fixation is as good as it is when the spot is not moving.

It is known[3] that moderate doses of barbiturates produce a nystagmus in normal subjects when the eyes are deviated to look at an object which is displaced from the forward direction. The slow phase of the nystagmus is towards the central position and the quick phase is towards the object. Fixation on an object directly in front of the subject is disorganized and random movements of the eyes occur.

It is of interest to know how barbiturates will affect the way in which the eyes pursue a moving object. Fig. 1*b* shows a record taken on the same occasion as Fig. 1*a* after the intravenous administration of 100 mgm. of 'Pentothal' in the course of 8 min. It can be seen that the ability of the eye to make smooth pursuing movements is abolished and it proceeds in a succession of jerks each one refixating the escaping spot.

A few further observations about visual tracking will permit an explanation of the effects of barbiturates. Smooth eye-movements are caused by the movement of the spot of light and not by its position. Fig. 2 shows the response of the eye to a spot which, initially stationary and straight ahead, moves instantly to the left and then proceeds with uniform velocity towards the right. The eye starts to move smoothly to the right although this is away from the position of the spot. The mechanism for smooth movements is aiming at achieving a stationary image on the retina irrespective of error in the position of fixation. Such an error is then corrected by a jerk provided that it exceeds about 0·1 deg. and some 200 msec. has elapsed since the previous jerk.

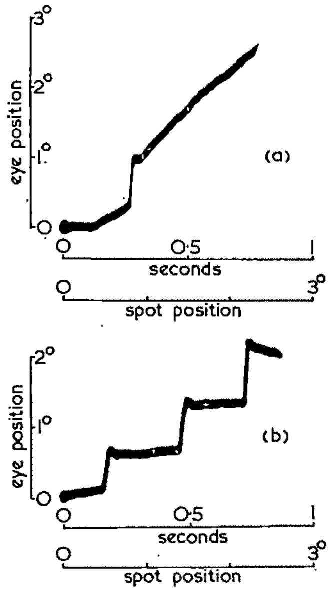

Fig. 1. Records of the eye-movements caused by watching a spot moving with constant velocity (*a*) before and (*b*) after the administration of 100 mgm. 'Pentothal' intravenously

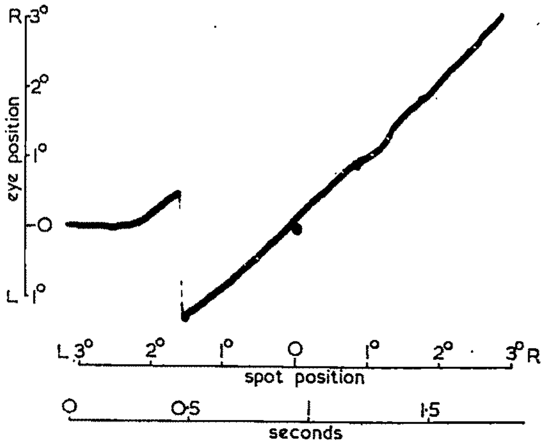

Fig. 2. Record of the eye-movement caused by watching a spot which is suddenly given a change of position in one direction and a velocity in the opposite direction

It is probable that no other mechanism is involved in fixating a stationary spot. When this is straight ahead, the eyes will be held stationary by the smooth mechanism except for very slow drifts in either direction[4] at velocities which are too slow for the eye to detect. When a sufficiently large error in position accumulates it will be corrected by a jerk. When the fixation spot is to one side the same things happen except that the drifts tend to be towards the centre[4].

Barbiturates abolish the smooth mechanism. Therefore, on forward fixation, spontaneous smooth movements of the eyes will not be prevented, and apparently random movements will occur with many refixation jerks. On deviated fixation these uncorrected smooth movements will be towards the centre with large outward refixation jerks at a rate up to 5/sec., this being the barbiturate nystagmus.

A description of the method used for recording eye movements and further details will be published elsewhere.

This work was assisted by a grant from the Bethlem Royal and Maudsley Hospitals Research Fund which is gratefully acknowledged.

C. Rashbass

Institute of Psychiatry,
Maudsley Hospital,
Denmark Hill,
London, S.E.5.

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Inhibition of Sensitiveness to Nicotine of Rabbit Aorta by Reserpine, Hexamethonium, Ethyl Flavone-7-Oxyacetate and Other Compounds

Burn and Rand[1] demonstrated that some spastic effects of nicotine on aortic strips can be abolished by a prophylactic treatment with reserpine. The present investigation was conducted in order to study

Table 1. SUBSTANCES WHICH PROVOKE A SUBMAXIMAL CONTRACTION OF THE AORTIC CHAIN

Substance	Concentration (μgm./ml.)
Adrenaline (on aortic chains of normal rabbits)	0·4–0·8
Adrenaline (on aortic chains of reserpine-treated rabbits)	0·2–0·4
Acetylcholine chloride	2–10
Histamine dihydrochloride	0·25
5-Hydroxytryptamine	1
Barium chloride	>150
Nicotine sulphate (on the fresh aortic chain)	~150
Nicotine sulphate (on the aortic chain sensitized by adrenaline)	2·5–15

how reserpine or other drugs are able to prevent the spastic activity of nicotine on this blood vessel.

The experiments were carried out on chains obtained by binding together about eighteen 2-mm. wide rings cut from the thoracic aorta of a rabbit. The chains were suspended in Ringer–Locke solution, aerated with oxygen at 37° C., and the contractions recorded. The active concentrations of nicotine and some other substances, able to cause a contraction of the aortic chain, are reported in Table 1. Nicotine itself, scarcely active on the fresh preparation, becomes very active after 2–4 contractions induced by adrenaline, histamine or acetylcholine.

Up to a concentration of 200 μgm./ml., nicotine did not cause any contraction if 0·5 mgm./kgm. reserpine had been daily administered subcutaneously, in the four days before the experiment, to the rabbits the aortic chains of which were used. This treatment did not affect the spastic activities of the other agents listed in Table 1.

On the other hand, reserpine added directly to the perfusion fluid up to a concentration of 3 μgm./ml. did not affect the sensitiveness of chains to nicotine; with higher concentrations an interference due to solvents was observed.

In order to investigate the mechanism of the action of nicotine, the activities of some antagonistic drugs were tested against the contractions induced by nicotine (Table 2) and some other drugs (Table 3).

Table 2. INHIBITION OF NICOTINE CONTRACTIONS OF THE AORTIC CHAIN

Substance	*ED*50 (μgm./ml.)*
Atropine sulphate	5
Dihydroergotamine	16
Hexamethonium	0·25
Pyrilamine hydrochloride	2·5
Reserpine	>3†
Papaverine hydrochloride	40
Ethyl flavone-7-oxyacetate	40
Aminophylline	160

* Concentration that inhibited by 50 per cent the contractions of the aortic chain due to 5 μgm./ml. of nicotine sulphate.

† With higher concentrations an inhibition due to the solvents was observed.

Table 3. INHIBITOR ACTIVITY AGAINST SOME STIMULATING AGENTS

Stimulating agent	Inhibitor	*ED*50 of the inhibitor (μgm./ml.)
Acetylcholine chloride, 5 μgm./ml.	Atropine sulphate	0·02
Adrenaline, 0·5 μgm./ml.	Dihydroergotamine	15
Adrenaline, 0·5 μgm./ml.	Hexamethonium	>150
Histamine dihydrochloride, 0·25 μgm./ml.	Pyrilamine hydrochloride	0·001

Since atropine and pyrilamine are much more effective in counteracting acetylcholine and histamine-induced spasm than nicotine contractions, the latter probably are not due to an acetylcholine or histamine liberation. On the other hand, dihydroergotamine antagonizes adrenaline-induced contractions at the same concentration as nicotine-induced contractions, and therefore it is possible that arterial nicotinic spasm is mediated through adrenaline or adrenaline-like substances. This conclusion is also supported by the characteristics of the activity of reserpine, which is able to inhibit the sensitivity to nicotine only if administered to the animals for some days, while the same drug is inactive if put directly in contact with the aortic chain. Probably, when chronically administered, reserpine depletes the aorta[1] as well as some other organs[2] of catecholamines and therefore nicotine cannot liberate adrenaline-like substances in the aortic chains of animals treated with reserpine.

The high inhibitory activity of hexamethonium against nicotine contractions could be easily explained if aortic sympathetic ganglia were stimulated by nicotine and blocked by hexamethonium. Since aortic sympathetic ganglia have not yet been demonstrated, an antagonistic effect of hexamethonium on a direct liberation of sympathetic substances from the cells due to nicotine may be possible.

The inhibiting mechanism of papaverine and ethyl flavone-7-oxyacetate, two powerful spasmolytics and coronary dilators, is probably a myotropic one.

As a result of this work, reserpine therapy in vascular diseases due to smoking is suggested. A combined treatment with some other nicotine contraction inhibitors, particularly with ethyl flavone-7-oxyacetate, might also be of some value, because this drug, compared with the others listed in Table 2, has a very low general toxicity.

I. SETNIKAR
M. RAVASI

Research Department,
Recordati Laboratorio Farmacologico S.p.A.,
Milan.
Jan. 7.

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PLANT PHYSIOLOGY

Absence of Gibberellin-like Substances in Filtrates of *Marasmius perniciosus* Stahel (Witch Broom Disease of Cacao)

CACAO plants (*Theobroma cacao*) infected with *Marasmius perniciosus* produce excessive and abnormal branching, a condition known as witch broom disease. It has been suggested by Brian[1] that symptoms may be caused by the production of growth-stimulatory or auxin-like substances by the pathogen. The morphological effects of gibberellic acid sprayed on cacao seedlings suggested that the 'brooming' effect of *M. perniciosus* might be caused by the production *in vivo* of gibberellin-like compounds by the fungus (Nichols, unpublished data).

This communication describes an attempt made to detect the production of growth-stimulatory substances or gibberellin-like compounds from a strain of *M. perniciosus* freshly isolated from an infected cacao tree, by the application of culture filtrates and expressed cytoplasmic constituents to cacao and rice seedlings (*Oryza sativa*). These two test species were chosen because cacao is one of the host plants of *M. perniciosus*, and rice is known to respond to gibberellic acid. Plants treated with the uninoculated medium were used as controls, and plants treated with culture filtrates of *Fusarium moniliforme* grown in the same medium were used as an index of the production and behaviour of gibberellic acid. Preliminary experiments with gibberellic acid confirmed that rice seedlings responded to application of the solution of the acid under the conditions of our test.

In order to prepare culture filtrates, the organisms were grown on the following medium, which gave good growth: hydrolysed molasses, 20·6 gm./l. total sugar; ammonium sulphate, 3 gm./l.; potassium dihydrogen phosphate, 3 gm./l.; 'Marmite', 5 gm./l. The medium was adjusted to *p*H 6·3 and dispensed in 100-ml. amounts in indented 250-ml. conical flasks. The cultures were grown on a rotary shaker at tropical room temperature (26–29° C.) for 20 days, by which time sugar utilization was complete (97 per cent). The cultures (20 flasks) of each organism were combined and filtered through sintered glass, after which the sugar concentration in the clear filtrates was restored to that in the uninoculated medium by the addition of equal amounts of glucose and fructose. The *p*H was also adjusted to its initial value. The culture filtrates and control medium were concentrated eight-fold by evaporation under reduced pressure at 40° C.

The effect of the concentrated filtrates on growth was examined by application of 0·1-ml. amounts to the terminal buds of cacao seedlings about 4 weeks from germination, grown in seed boxes. Each solution was tested on 12 plants. The plants were treated twice-weekly at 3- and 4-days intervals for a total period of 4 weeks. Concentrated and unconcentrated filtrates were tested in this manner. The *Fusarium* filtrates gave a marked elongation of the stem by typical internode elongation as compared with the control plants, but no effect either stimulatory or inhibitory was observed with the *Marasmius* filtrates. Similar results were obtained when the filtrates were applied to rice seedlings.

Despite the negative results with cultures grown *in vitro*, it remained possible that the substances responsible for the growth abnormalities of cacao were produced by the *Marasmius in vivo* in the host plant. This possibility was examined by treating seedlings with an extract of infected cacao tissue. The extract was prepared by macerating freshly collected witch broom branches (250 gm.) in a Waring blendor with a little water and expressing the mucilaginous pulp through several layers of cotton gauze. The filtrate was concentrated approximately ten-fold by evaporation to a thick gel in a freeze-drying apparatus. Cacao seedlings were treated by application of the extract to the stem just below the terminal bud. Some of the seedlings were pricked after the initial application to ensure entry of the extract into the plants. Treatment was continued twice weekly for 4 weeks. The extract had no effect whatsoever on the growth-rate relative to untreated control plants. These experiments suggest that *M. perniciosus* does not produce a detectable growth-stimulatory substance similar to gibberellic acid under the conditions of the culture and test whereas *F. moniliforme* does.

The strain of *F. moniliforme* (N.R.R.L. 2284) was kindly supplied by Dr. C. W. Hesseltine and the gibberellic acid by Dr. P. W. Brian.

W. F. Dudman
Colonial Microbiological Research Institute,
Port-of-Spain, Trinidad.

R. Nichols
Regional Research Centre,
Imperial College of Tropical Agriculture,
Trinidad.

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Interaction of Magnesium and Adenosine Diphosphate in Photosynthetic Phosphorylation

A critical ratio of magnesium and the adenosine phosphates has been observed in several enzymically catalysed reactions. Hers[1] demonstrated that maximal activity in the hexokinase and fructokinase reactions occurred when the magnesium/adenosine triphosphate ratio was one. The rate of formation of adenosine diphosphate from adenosine monophosphate and adenosine triphosphate, catalysed by myokinase, was maximal when the magnesium/adenosine triphosphate ratio was one; in the reverse reaction, maximal activity was observed when the ratio was one half[2]. A definite stoichiometry between adenosine triphosphate and manganese also has been found, for Lowenstein[3] observed that maximal activity in a non-enzymic transphosphorylation occurred when the manganese/adenosine triphosphate ratio was approximately 1·7.

Arnon *et al.*[4] reported that magnesium enhanced photosynthetic phosphorylation. Avron *et al.*[5] have given results of the saturation of photosynthetic phosphorylation by magnesium and adenosine diphosphate in the presence of constant amounts of adenosine diphosphate and magnesium, respectively. It may be calculated from their results that in the presence of 1·5 μmoles adenosine diphosphate the system was saturated by 2·5–3 μmoles magnesium; in the presence of 5 μmoles magnesium the system was saturated by 2·25–2·5 μmoles adenosine diphosphate. Thus saturation was reached when the magnesium/adenosine diphosphate ratio was two. We have performed additional experiments, the results of which indicate that a definite ratio of magnesium and adenosine diphosphate is necessary for optimal photosynthetic phosphorylation.

Chloroplasts were prepared by grinding 25 gm. of spinach leaves, from which the petioles and mid-ribs had been removed, with sand and 25 ml. homogenizing solution in a mortar. The homogenizing solution was 0·02 *M* with respect to *tris* buffer *p*H 8·0, 0·3 *M* with respect to sucrose, and 0·004 *M* with respect to sodium chloride. Cellular debris was removed by filtering through cheese-cloth. The juice was centrifuged at 100*g* for 1 min., and this supernatant was centrifuged for 7 min. at 1,000*g*. The sedimented chloroplasts were suspended in 5 or 10 ml. of the homogenizing solution. These operations were performed at 5° C. Chlorophyll concentration was determined by Arnon's method[6].

The phosphorylation reaction was performed in Thunberg tubes. The reaction mixture contained 50 μmoles *tris* buffer *p*H 8·0, 80 μmoles sodium chloride, 20 μmoles dipotassium hydrogen phosphate, 10 μmoles ascorbate, 0·1 μmole flavin mononucleotide, 0·1 ml. chloroplast preparation (50–100 μgm.

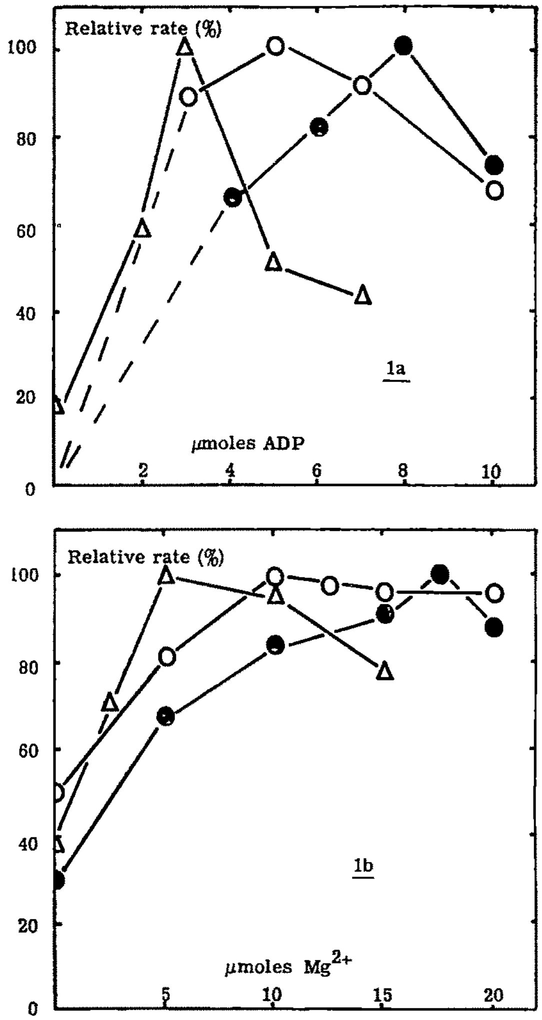

Fig. 1. *a*, Effect of concentration of adenosine diphosphate on photosynthetic phosphorylation. △, 5 µmoles magnesium; ○, 10 µmoles magnesium; ●, 15 µmoles magnesium. The rates corresponding to 100 per cent for △, ○ and ● were 70, 140 and 110 µmoles phosphate esterified/mgm. chlorophyll/hr., respectively. *b*, Effect of concentration of magnesium on photosynthetic phosphorylation. △, 3 µmoles adenosine diphosphate; ○, 5 µmoles adenosine diphosphate; ●, 8 µmoles adenosine diphosphate. The rates corresponding to 100 per cent for △, ○ and ● were 155, 100 and 104 µmoles phosphate esterified/mgm. chlorophyll/hr., respectively

chlorophyll), magnesium sulphate, adenosine diphosphate and water in a total volume of 3·0 ml. After trials had showed that phosphorylation occurred aerobically as well as anaerobically, all reactions were run in an atmosphere of air. The reaction vessels were held in a water-bath at 15° C. Illumination was provided by 150-watt reflector flood lights (intensity measured with a barrier layer photocell was approximately 1,800 foot candles). The reaction was allowed to proceed for 20 min., after which 0·5 ml. 20 per cent trichloracetic acid was added to each tube. Trichloracetic acid was added to control vessels either directly after the addition of chloroplasts or after 20 min. in darkness. The nucleotides were separated from inorganic phosphate by the method of Crane and Lipmann[7]. Phosphate was determined by the method of Taussky and Shorr[8]. Rates of phosphorylation were calculated from the disappearance of inorganic phosphate. The increase of organic phosphate was determined by hydrolysing the adsorbed nucleotides, but this increase was usually 5–20 per cent less than the amount of inorganic phosphate disappearing.

Fig. 1*a* shows the effect of adenosine diphosphate concentration on the rates of photosynthetic phosphorylation in the presence of three concentrations of magnesium. In the three cases the optimal rates of phosphorylation were observed when the magnesium/adenosine diphosphate ratio was 2. Fig. 1*b* shows the influence of magnesium concentration on the rates of photosynthetic phosphorylation in the presence of three concentrations of adenosine diphosphate. In these experiments also, optimal activity was observed when the magnesium/adenosine diphosphate ratio was 2. Magnesium usually showed a saturation effect ; but in some instances inhibition was observed at higher concentrations.

It is clear that a definite magnesium/adenosine diphosphate ratio is necessary for optimal photosynthetic phosphorylation. Magnesium may affect more than one reaction in the process of photosynthetic phosphorylation; however, information on the overall reaction still is insufficient to evaluate the significance of the magnesium/adenosine diphosphate ratio of two.

This communication is published by permission of the Director of the Wisconsin Agricultural Experiment Station. The work was supported in part by a grant from the National Institutes of Health.

J. B. Mudd

Department of Biochemistry,
University of Wisconsin,
Madison 6, Wisconsin. Jan. 5.

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Synergistic Effect of Zinc and Gibberellin

Dwarf beans (*Phaseolus vulgaris*) were sown in John Innes seed compost and, when emergence had occurred, the seedlings were transplanted into 2½-in. pots using the John Innes potting compost.

The plants were put in a growth room maintained at 60° F. and illuminated for 15 hr. a day with a bank of fluorescent lights giving 500–600 foot candles at the primary leaf surface of the beans. The plots were arranged in three 4 × 4 Latin squares, and 0·5 ml. gibberellic acid solution containing 500 mgm./l. 'Gibrel' was applied to the leaves of half the plants when elongation of the apical bud had commenced. ('Gibrel' is the potassium salt of gibberellic acid as produced by Merck and Co., Rahway, N.J., U.S.A.) 24 hr. later half the gibberellin-treated and half the remaining plants were treated with 0·5 ml. 10^{-2} *M* solution of zinc sulphate. Thus four treatments were obtained: 0, control; 0 + Zn, 10^{-2} *M* zinc sulphate; G, gibberellin solution; G + Zn, gibberellin plus zinc solution.

The elongation of the second internode, that is, that between the first and second trifoliate leaves, was measured one week after the application of the gibberellin. A further measurement was taken three days later.

There was a significant difference between the gibberellin treatment and controls, as would be

Table 1. THE EFFECT OF ZINC ON THE RESPONSE OF DWARF BEAN PLANTS TO GIBBERELLIN

Treatment	Stem elongation (mm.) recorded after treatment 7 days	10 days
0	3·8	5·9
0 + Zn	4·8	8·1
G	15·2	52·8
G + Zn	20·8	70·6
Difference required for significance		
P (0·05)	4·1	10·1
P (0·01)	5·6	13·7

expected, but there was also a significant effect ($P = 0 \cdot 01$) between those treated with gibberellin and gibberellin plus zinc solution, the addition of zinc sulphate solution to plants already treated with gibberellin increasing the growth response. Solutions of sulphates of iron, manganese and potassium have not given similar increases in response and one (copper sulphate) reduced growth significantly. It is therefore assumed that the zinc ion was responsible for the effect reported here.

There was a slight, although not statistically significant, increase in the internode-length of plants treated with zinc alone, which may possibly have been due to the effect of the ion on the naturally occurring gibberellin-like substances in the plant.

This work was a continuation of studies started in the Department of Vegetable Crops, Cornell University. The gift of 'Gibrel' from Dr. J. Merritt of the Merck Chemical Co. is acknowledged.

JOHN DANCER
Department of Horticulture,
University of Nottingham School of Agriculture,
Sutton Bonington,
Loughborough. Jan. 5.

MICROBIOLOGY

Endogenous Metabolism of Freshly Harvested Cells of a Brewer's Yeast

WASHED cell suspensions of yeast have been reported as being able to respire their carbohydrate reserves but unable to ferment these reserves even when the cells were freshly harvested[1,2]. Other workers have reported that an alcoholic fermentation of these reserves is induced in the presence of dinitrophenol, azide and arsenite[3,4]. In the present work it has been found that in a brewer's yeast (*Saccharomyces cerevisiae*) the carbohydrate reserves are degraded by a fermentation process under both aerobic and anaerobic conditions. As a result of this fermentation the total carbohydrate content of the yeast in a suspension at 28° C. decreased by as much as 50 per cent in the 5 hr. following harvesting. The decrease in the trehalose and glycogen fractions accounted for all the loss of carbohydrate.

The yeast was grown up in the medium described by Spiegelman and Nozawa[2]. The incubation temperature was 25° C. The cultures were harvested after 48 hr., washed three times by suspension and centrifugation in $M/15$ potassium dihydrogen phosphate (pH 4·5) and then suspended in the same solution. Manometric measurements of respiration and fermentation were by the direct Warburg method at 28° C. The first manometric readings were always taken less than an hour after harvesting. Yeast carbohydrate was fractionated by the scheme described by Trevelyan and Harrison[5] and measured by an anthrone procedure. Ethanol in the suspending medium was distilled off and determined with liver alcohol dehydrogenase. Dry weights were determined after 48 hr. at 100° C. At the end of each experiment the yeast suspension was examined by the methylene blue technique. The number of cells taking up the dye was always negligible and there was never any evidence of autolysis. No bacterial contamination was ever observed.

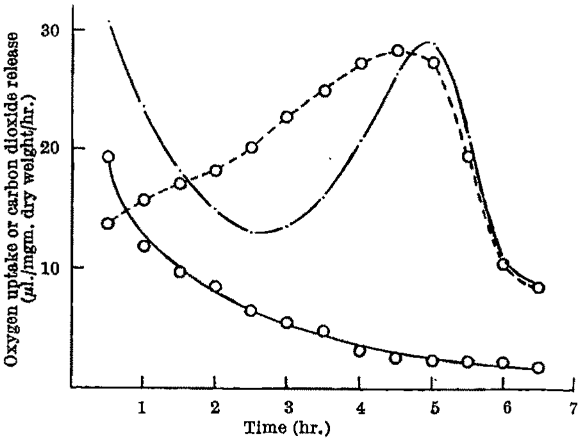

Fig. 1. Each Warburg flask contained 5·8 mgm. (initial dry-weight) of yeast in 3 ml. of *M*/15 potassium dihydrogen phosphate. $Q_{CO_2}(N_2)$, O——O ; Q_{O_2}, O- - - O ; Q_{CO_2}, ·——·

In a series of experiments under anaerobic conditions the decrease in carbohydrate was 85–100 per cent of the amount calculated from the carbon dioxide released (assuming that each glucose molecule in the reserve carbohydrate produces two molecules of carbon dioxide and two molecules of ethanol during the fermentation). The ethanol which accumulated under anaerobic conditions was about 70 per cent of the amount expected from the carbon dioxide released. The $Q_{CO_2}(N_2)$ (µl. of carbon dioxide released per mgm. initial dry-weight of yeast per hour) had an initial value of 16–20 and decreased with time (Fig. 1). In other experiments where the release of carbon dioxide was followed for 9 hr. the $Q_{CO_2}(N_2)$ at the end of this period was still measurable.

Under aerobic conditions the endogenous fermentation was made apparent by a high initial respiratory quotient (1·9–2·5) and the production of ethanol. The ethanol accumulated for 2 hr. and then disappeared from the suspension. The time course of the endogenous metabolism is shown in Fig. 1. Q_{O_2} (µl. of oxygen taken up per mgm. initial dry-weight of yeast per hour) in these experiments had an initial value of 12–14 and then increased to about 28 in about 4½ hr. before falling steeply. Q_{CO_2} had an initial value of 28–32, which decreased for about 2½ hr. before increasing again to the same level as Q_{O_2}.

The apparent respiratory quotient falls rapidly from its high initial value to about 0·6 after about

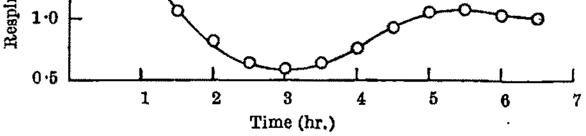

Fig. 2. Apparent respiratory quotient

3 hr. before increasing again to a constant value of about 1·03 (Fig. 2).

Most of the work carried out on the endogenous metabolism of yeast has been on cell suspensions[1–4], but in 1901 Harden and Rowland[6] described an endogenous fermentation in pressed brewer's yeast, resulting in the production of about equimolecular amounts of alcohol and carbon dioxide. These results with pressed yeast have been questioned[1,2,7] because of the possibility that the cells might have been damaged mechanically during the pressing process. The present work with cell suspensions shows that the brewer's yeast used in these experiments does degrade its reserve carbohydrate by a fermentation process, and at the same time the rate of respiration of the yeast doubles.

It is hoped to publish these results in greater detail elsewhere.

I wish to thank the directors of Arthur Guinness Son and Co. (Park Royal), Ltd., for permission to publish this work.

V. E. CHESTER

Arthur Guinness Son and Co. (Park Royal), Ltd.,
Laboratory,
Park Royal Brewery,
London, N.W.10.
Nov. 11.

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Allyl Alcohol as a Nutrient for Micro-organisms

ALLYL alcohol has in recent years come into some use as a herbicide active against dormant seed. Experiments in progress in this Laboratory have shown that this compound is rapidly detoxicated by biological agencies when added to soil at the rate of 0·02–0·05 per cent; various bacteria capable of utilizing it for growth were isolated from enrichment cultures by plating on selective agar medium. (A few earlier investigators[1,2] have tested allyl alcohol with negative results as a carbon source for fungi and bacteria.)

The active bacteria were partly varieties probably of *Pseudomonas fluorescens* and *P. putida* and partly strains of *Nocardia corallina*. Their growth was tested in soil extract medium containing 0·5 per cent (vol.) allyl alcohol, 0·05 per cent ammonium sulphate, 0·05 per cent dipotassium phosphate and 0·02 per cent magnesium sulphate. Duplicate cultures were grown for one week on a rotating shaker at 25° C., the cells were collected by centrifugation and the amount of growth was measured by determination of nitrogen in the washed-cell deposit. Some representative results are shown in Table 1.

Table 1

Organisms	Cell nitrogen (mgm.) from 100 ml. medium		
		+ Allyl alcohol	Control
Pseudomonas spp. (7 strains)	Min.	2·2	0·2
	Max.	6·8	0·5
	Mean	5·0	0·4
Nocardia corallina (3 strains)	Min.	3·2	0·3
	Max.	4·8	0·5
	Mean	4·1	0·4

Only 2 among 22 strains of *Pseudomonas* spp. isolated by non-selective methods were able to utilize allyl alcohol. Several bacteria belonging to other genera were tested qualitatively with negative results. All bacteria that grew with allyl alcohol could also utilize propanol and sodium propionate, but the reverse did not apply. Among 40 strains of *Azotobacter* and *Beijerinckia* spp. two strains of *A. vinelandii* and one of *A. insigne* utilized allyl alcohol for nitrogen fixation; some 14–20 mgm. nitrogen were fixed per gm. of allyl alcohol supplied.

Also several strains of the fungus *Trichoderma viride* were able to use allyl alcohol for growth. Table 2 shows results found with seven strains grown for 20 days at 25° C. as stationary cultures in soil extract medium with 0·5 per cent (vol.) allyl alcohol. Four of these strains were isolated from selective medium and the rest non-selectively; the two groups of strains showed no essential difference.

Table 2

Dry weight of mycelium, mgm. per 100 ml. medium		
	+ Allyl alcohol	Control
Min.	14	1
Max.	169	5
Mean	90	3

A number of other fungi, collection cultures as well as random isolates from soil, were tested qualitatively with negative results; among these were also some strains of *Trichoderma viride*.

Experiments on the rate and mechanism of biological detoxication of allyl alcohol are in progress; the results will be published elsewhere.

I am indebted to Dr. Hans Lautrop, Statens Seruminstitut, Copenhagen, for supplying me with a number of strains of *Pseudomonas* spp.

H. L. JENSEN

State Laboratory for Soil and Crop Research,
Department of Bacteriology,
Lyngby, Denmark.
Jan. 5.

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Mode of Division of Pediococci

THE differentiation of pediococci from other groups of spherical lactic acid bacteria has frequently been based on the characteristic morphological arrangement into tetrads[1–3]. It has been generally assumed that the occurrence of tetrads is attributable to division in two planes[1,3]. However, some workers[4,5] have expressed the view that pediococci divide in one plane only, giving rise to chains similar to those formed by streptococci, and that tetrad formation is due to re-arrangement of 3–4 membered chains.

In all these investigations the mode of division has been deduced from examination of stained preparations only. It was decided, therefore, to follow the sequence of division of several strains, starting from single cells, by direct microscopic observation of developing slide cultures under a phase-contrast microscope. The cultures were made on semi-solid

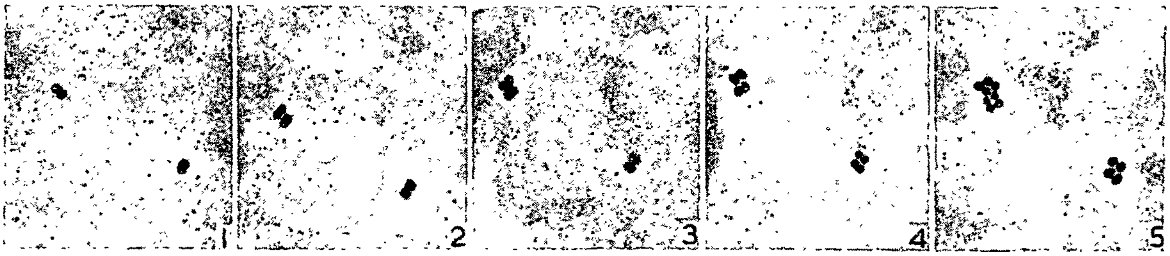

Fig. 1. Photomicrographs of division of *Pediococcus cerevisiae* strain 8081. Incubation for: (1), 0 hr.; (2), 1 hr. 45 min.; (3), 2 hr. 20 min.; (4), 3 hr. 20 min.; (5), 6 hr. 15 min. (× *c.* 710)

agar (tomato or glucose-yeast broth, *p*H 6·8 with 0·5 per cent Davis agar) and the microscope was fitted with a Newman Waterfield warm stage adjusted to 30° C. Series of photomicrographs were taken during the course of these observations, and one such series, which is representative of the sequence of divisions shown by all strains of pediococci studied, is reproduced in Fig. 1. The photomicrographs demonstrate clearly that division of pediococci occurs in two planes, and that successive divisions are approximately at right angles to each other.

Representatives of the streptococci, micrococci and sarcinae, studied under identical conditions, exhibited the typical modes of division associated with their respective groups.

The results of these experiments indicate clearly that the mode of division of the pediococci differs from that of the streptococci. In addition to their physiological differences, the two groups of organisms may be distinguished, therefore, on the basis of their morphology.

This work was undertaken during the tenure of a postgraduate scholarship awarded by Queen Elizabeth College (University of London).

HELGE-LIANE GUNTHER*

Department of Bacteriology,
Queen Elizabeth College,
University of London,
London, W.8. Jan. 7.

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* Present address: Department of Pharmacology, Yale University School of Medicine, New Haven, Conn.

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A Gram-negative Sporing Bacterium from the Rumen

REPORTS in the literature of Gram-negative sporing bacteria are comparatively rare, although recently three have been mentioned[1-3], two from the rumen contents of cattle or sheep. We have obtained some Gram-negative sporing organisms during investigation of rumen bacteria. Three isolations were obtained from Gram-negative rods of the genera *Bacteroides* and *Butyrivibrio*[4] which had been isolated at different times from the rumens of sheep or cattle using a strictly anaerobic technique, based on that of Hungate[5], with either xylose or xylan as carbohydrate. Sporing forms were first noted on reculturing freeze-dried cultures. It seemed unlikely that the sporing bacteria were airborne contaminants, and although they were, under some conditions, very similar in morphology to the *Bacteroides* and *Butyrivibrio* spp. their properties always differed from these bacteria even after continued anaerobic culturing.

Two pure cultures of the sporing organism were obtained from the mixed cultures by micro-manipulation and culture of single spores, and a third by heat treatment of a sporing culture. A fourth isolation was made from the rumen contents of a sheep (not the one from which the original cultures were obtained). Although occasional sporing organisms of this type were seen in cultures made from dilutions of rumen fluid under anaerobic conditions it did not prove possible to isolate them anaerobically or by anaerobic followed by aerobic culture, so it was decided to use an aerobic technique, with xylose as carbohydrate, as this would destroy the similar Gram-negative non-sporing rods. To prevent overgrowth by other facultatively anaerobic organisms common to the rumen contents, penicillin (10 units/ml.) was incorporated in the diluting fluid and culture medium. Growth was obtained only to a dilution of rumen contents of 10^{-2}, and an isolation was made from the first dilution. All four isolations were similar straight or slightly curved rods (1·8–3μ × 0·8μ, but longer forms were seen), Gram-negative when stained in conjunction with known Gram-positive and -negative organisms, and having subterminal oval spores. Very occasional Gram-positive forms were also seen. Occasional motile cells were found, with a terminal flagellum. All grew aerobically or anaerobically, but better growth, and a lower *p*H in sugar media, were usually obtained aerobically. The spores of one isolation survived heating in physiological saline suspension in a boiling water-bath for 20 min., but were killed after 40 min.

Sugar fermentations were tested in a medium containing yeast extract and mineral salts incubated under carbon dioxide or aerobically. The fall in *p*H resulting from growth in sugar-containing media was not usually very great, and all reactions were checked with a Pye *p*H meter, a fall from 6·9 to 5·9 being considered positive. Xylose, glucose, fructose, mannose, galactose, lactose, cellobiose, melibiose, xylan, dextrin and amylopectin were fermented by all isolations with no visible gas formation. The fermentations of arabinose, maltose, trehalose, raffinose, glycogen, mannitol and α-methyl glucose were variable or indefinite. Rhamnose, fucose, inulin, salicin, æsculin, sorbitol, dulcitol, adonitol, glycerol, sodium succinate, lactate, malate, fumarate and citrate, were not fermented. Nitrate reduction, methyl red reaction and catalase production were positive. Voges-Proskauer and indole reactions, ammonia and hydrogen sulphide production, and urea and gelatin hydrolysis were negative. No growth was obtained in Koser's citrate medium, and the final *p*H in glucose–peptone broth was 5·2–5·6. Litmus milk was decolorized but no clot formed. The products of fermentation of xylose, chosen to compare these bacteria with the *Bacteroides* and *Butyrivibrio* spp., were formic, acetic and lactic acids in the equivalent proportions 19 : 17 : 1. Succinic acid was not determined.

Antisera were prepared by inoculation of formolized suspensions into rabbits. Cross-agglutinations were found between the culture isolated directly from the rumen and the isolate from the culture of a sheep rumen bacterium. The two isolations from cultures of cattle rumen bacteria appeared to be serologically different from those of sheep. The one isolate tested was also different from the culture of *Bacteroides* sp. from which it was originally isolated.

In biochemical properties the bacteria resemble *Bacillus circulans*, but no motile colonies have been noted, although the growth was very thin and spreading on plates. It is not known whether the organisms play any part in rumen metabolism, although they must at times be present in fairly high numbers to have been isolated along with the cultures of *Bacteroides* and *Butyrivibrio* since these were taken from quite high dilutions of rumen contents. Appleby[6] isolated from the sheep rumen along with other proteolytic bacilli one culture, identified as *Bacillus circulans*, which liquefied gelatin. The Gram-negative sporing bacterium isolated by Gray[2] from the sheep rumen is said to resemble *Clostridium kluyverii* in properties. The present bacteria are somewhat similar in morphology to organisms described by Gutierrez[3], which were ingested by the rumen protozoan *Isotricha prostoma*, and possibly served as a nitrogen source for this protozoan.

We would like to thank Dr. K. I. Johnstone of the University of Leeds for obtaining one single-spore culture and for instruction in his micromanipulation technique to one of us (M. R. P.), Miss M. Garvock for the acid analyses, and Mr. S. O. Mann for discussion.

P. N. Hobson
M. R. Purdom

Rowett Research Institute,
Bucksburn,
Aberdeenshire.
Jan. 12.

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GENETICS

A New Physical Method of creating Chromosomal Aberrations

Recent observations in this laboratory[1,2] have indicated a wide and unusual spectrum of effects which can be obtained from a radio-frequency source in the megacycle range. In order to minimize dielectric heating, it was necessary to reduce the mean power input and therefore we have used a pulsed radio-frequency source at 27 Mc./s. The pulses are of the order of 5×10^{-5} sec. Most of the effects described herein are produced with between 80 and 180 pulses per sec.

For microscopical and genetic studies we used two electrodes separated by an air gap of 3–15 mm. The electrodes were coupled to the primary radio-frequency source. There is a peak-to-peak voltage of about 1,000–1,500 V. The microscopic and genetic preparations were insulated from the electrodes by two layers of glass. It can be observed that a large variety of substances, including iron, carbon, silver, oil, fat droplets, starch grains and mammalian cells, will react to this field in two ways. First, any asymmetrical particle will be oriented with its long axis along the lines of force. Secondly, after orientation (which, of course, is not observed in symmetrical particles such as spheres) these particles will form chains along the lines of force as though they were iron filings between two poles of a magnet.

One of the most dramatic demonstrations of this effect can be seen when motile bacteria or protozoa are in this field. When the field is impressed, the micro-organisms can migrate only along the lines of force. As soon as the field is turned off, they resume their random movement. This can be repeated as many times as desired.

The thermal component is obviously sufficiently low so as not to affect the viability of these organisms or mammalian cells. In a larger, immobilized

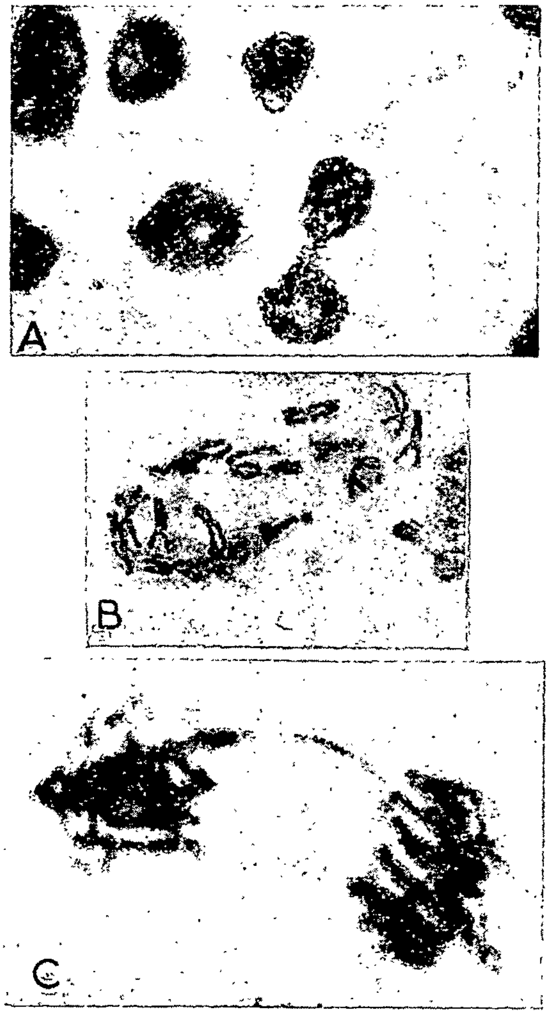

Fig. 1. Squash preparation of garlic root-tips 24 hr. after 5 min. of exposure in the electromagnetic field. *A*, Resting stage of an irradiated cell showing two nuclei linked by a chromatic bridge and no cytodieresis; *B*, metaphase with linear shortening of chromosomes; *C*, bridging

micro-organism we were able to observe intracellular orientation of subcellular particles. This led us to believe that this force might be used as a powerful and controlled mutagenic agent. Growing garlic root-tips in water were placed in a field between two insulated electrodes. No temperature increase in the water was noted. The tips were exposed for a 5-min. period and examined 24 hr. later.

Among those aberrations seen were linear shortening of chromosomes, pseudochiasmata, amitotic division, bridging, irregularities in the chromosomal envelope. The effects noted mimicked those produced by ionizing radiation and *c*-mitotic substances.

Fig. 1 shows some of the chromosomal aberrations observed. It is believed that this represents a new tool which may induce chromosomal aberrations to a degree contingent upon frequency, pulse, power, exposure time, and the axis of the cell *vis-à-vis* the field. Further experiments on the physical basis of these changes, as well as chromosome and mutation studies on other materials, are at present under investigation.

JOHN H. HELLER
A. A. TEIXEIRA-PINTO*

New England Institute for Medical Research,
Ridgefield, Connecticut.
Dec. 24.

* Gulbenkian Foundation Research Fellow.

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Preliminary Information on the Genetics of Ethiopian Coffees

LITTLE is known about the genetic variability of the species *Coffea arabica* in its native home—south-west Ethiopia. Recently, however, seed samples of wild, cultivated and subspontaneous coffees in this region have been gathered by various agriculturists[1,2]. Several small seedling populations from Ethiopia were sent here in 1952 and 1953, and the genetic constitution of some of them is now being worked out.

It was noted that the 'Erithrean moca' coffee (*PI* 205 413, U.S. Dept. Agric.) is identical with the *semperflorens* mutant, being homozygous for the alleles *sfsf*[1].

The results of artificial pollination with the *murta* variety (*ttNana*) revealed that from 33 analysed coffee plants from Ethiopia, 23 carry the alleles *tt*, probably in the homozygous condition. The alleles *tt* characterize the variety *bourbon*, and its presence in Ethiopia indicates that this region and not Reunion Island, as formerly thought, is the place of origin of this important commercial variety. The *typica* variety (*TTNaNa*) also occurs in Ethiopia.

Plants of the *abyssinica* variety were frequently found in some of the seedling populations. Although the alleles responsible for its main characters are not yet known, it was noted that *abyssinica* plants carry the alleles *TT*. Other populations segregating for *abyssinica* characteristics bear the alleles *tt*. The coffee type *Ennarea* or *Ennaria*[1] does not seem to belong to this variety.

The genetic analysis of the colour of the young leaves revealed that the allele *br* is frequently found in the imported plants. A new recessive allele, *semierecta* (*se*) with a phenotypic effect somewhat similar to the dominant allele *erecta* (*Er*), was observed[3]. Plants with large fruits and seeds, *macrocarpa*, were noted but no information is available with regard to their genetic constitution.

Coffee seedlings with a small foliaceous and persistent calyx were found in the populations of plants identified as *S.4-Agaro* (*PI* 205 408) and *S.6-Cioccie* (*PI* 205 411) coffee. In spite of having developed sepals, these plants do not carry the allele *sd*[4]. An interaction, however, seems to occur between the *sd* and the allele or alleles responsible for persistent sepals from Ethiopia.

Other variations concerning: leaf shape; their position on the lateral branches; fruit shape; colour of the berry; period of fruit ripening and vegetative vigour, were also found.

This rather intensive variability encountered in the seedlings received from Ethiopia may be the result of a non-randomized procedure of seed collection, seeds very often having intentionally been harvested from more or less conspicuous variants, occurring in the Ethiopian coffee forests. Possibly a higher amount of natural cross-pollination, occurring in the native habitat of *C. arabica*, may also be responsible for this marked genetic heterogeneity.

The occurrence of several new genetic factors in such a small sample of Ethiopian coffee indicates that further exploration for coffee mutants in Brazil is highly desirable, to throw more light on the genetics of *Coffea arabica* and also to provide more basic material for its improvement.

Acknowledgment is due to Dr. C. A. Krug for help in the preparation of this communication.

ALCIDES CARVALHO

Genetics Department,
Instituto Agronomico,
Campinas, São Paulo,
Brazil.
Jan. 5.

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BIOLOGY

Generic Nomenclature of the Intermediate Hosts of *Schistosoma mansoni*

IT has been shown by Hubendick[1] that the molluscan intermediate hosts of *Schistosoma mansoni* in Africa and South America are congeneric. The selection of the correct name for this genus of planorbid snails cannot be decided by a simple application of the rule of priority, because there is a conflict of opinion as to which is the oldest available name. The situation is further complicated by the fact that the names competing for precedence under the rule of priority are all quite unknown to the medical field workers and parasitologists who are frequently concerned in studies on these snails. An application has therefore been made to the International Commission on Zoological Nomenclature by Drs. F. S. Barbosa, B. Hubendick, E. A. Malek and myself asking for a decision which will stabilize the nomenclature of this economically most important group. It is probable that the decision of the Commission will not be made known for some time. It is for this reason that I am anxious to direct the attention of workers who may be concerned with these snails to the normal practice of adhering to existing nomenclature while an application is before the Commission. Thus, until a decision has been given, the generic name used for the African intermediate hosts of *Schistosoma mansoni* should be *Biomphalaria* and for the South American hosts either *Australorbis* or *Tropicorbis*.

C. A. Wright

British Museum (Natural History),
Cromwell Road,
London, S.W.7. Jan. 5.

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Effect of Gamma-Radiation on Weeds

Considerable data are now available on the radiosensitivity of cultivated plants[1,2], but very little is known about the tolerance of wild species. We have investigated the doses of γ-radiation needed to prevent weed seeds from growing. The seeds were stored at 32 per cent relative humidity and irradiated in air with a range of doses from 0 to 100,000 rads of γ-radiation from cobalt-60. They were then planted in steam-sterilized soil and the number of plants arriving at maturity were counted. *LD*50 values for some common species of arable weeds are listed in Table 1.

Table 1. *LD*50 Doses for Arable Weeds

Species	Chromosome number (ref. 3)	Approximate *LD*50 (rads)
Plantago major	12	10,000
Anisantha sterilis	14	5,000
Alopecurus agrestis	14	20,000
Papaver rhoeas	14	30,000
Medicago lupulina	16 or 32	80,000
Brassica nigra	16	100,000
Atriplex patula	18	10,000
Anthemis arvensis	18	20,000
Raphanus raphanistrum	18	20,000
Sinapis arvensis	18	100,000
Veronica persica	28	>100,000
Galeopsis tetrahit	32	10,000
Sonchus oleraceus	32	10,000
Capsella bursa-pastoris	32	100,000
Polyganum convolvulus	40	30,000
Senecio vulgaris	40	80,000
Rumex obtusifolius	40	100,000
Avena fatua	42	20,000
Avena ludoviciana	42	20,000
Euphorbia helioscopia	42	20,000
Papaver dubium	42	30,000
Stellaria media	42	60,000
Galium aparine	44, 66 or 88	80,000
Cerastium vulgatum	144	80,000

Fig. 1 shows the effects of radiation on *Alopecurus agrestis* planted at a rate of 50 seeds per box. Several characteristic radiation effects were observed. Germination was not related to survival, as irradiated seedlings were generally weaker than controls, and often had distorted first leaves. Seedlings which survived matured later than controls but were not obviously distinguishable otherwise : induced sterility was frequently noted. The *LD*50 doses could not be correlated with any simple character such as chromosome number, though all plants with high chromosome numbers were always radioresistant. The species studied fall into two groups, those with *LD*50 doses less than 30,000 rads and those with *LD*50 doses, greater than 60,000 rads. Apart from *Raphanus* all the crucifers examined come in the second group and the four grasses in the first. *Anisantha sterilis* is remarkably radiosensitive, whereas *Veronica persica* must be one of the most radioresistant plants known.

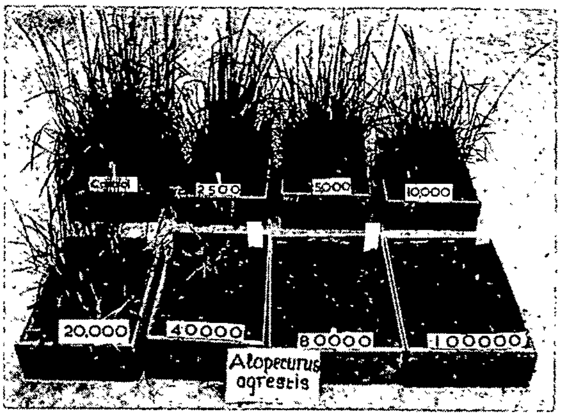

Fig. 1

The results obtained indicate that arable soils need treatment with at least 100,000 rads of γ-radiation to inhibit weed growth effectively. This treatment would sterilize any insects[4], or nematodes[5] present in the soil, and would probably destroy a high percentage of the bacteria[6,7] and fungi[7,8].

We wish to thank Mr. I. M. Rorison for supplying the seeds of *Papaver rhoeas* used in this work.

H. J. M. Bowen
S. R. Smith

Wantage Radiation Laboratory,
Grove, Berks.

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Seasonal Changes in the Brain-case of the Common Shrew (*Sorex araneus* L.)

It is well known that shrews of the genus *Sorex* undergo a striking seasonal fluctuation in average weight and length of body[1]. This is mainly brought about by the annual turnover of the population and the rapid spring growth associated with sexual maturation. An additional contributory factor is the decrease in weight of the sub-adults as the winter of their year of birth approaches. This has been detected in large field samples of *S. araneus*[2,3], *S. fumeus*[4] and *S. vagrans*[5].

It was completely unsuspected, until discovered by Dehnel[3], that the autumnal depression in size of body was accompanied by a shrinkage in the size of the skull, the most striking change occurring in depth of the brain-case. Cabon[6] found a similar seasonal fluctuation in brain-case depth in *S. minutus*, and established that this was associated with changes in brain volume. The same seasonal change has been demonstrated in Polish *Neomys fodiens*[7], and in a collection of north German *S. araneus* in the Berlin Museum[8].

We were not completely satisfied that differences in depth of brain-case, of the order shown by Dehnel and his associates, could not be due to chance and the inevitable errors incurred with calipers, particularly as the samples for the crucial months were small.

The difficulties of attaining consistent accuracy when measuring small skulls with hand-operated calipers are notorious, as are the difficulties of introducing mechanical aids. Micrometers for use in engineering are commonly fitted with a means of applying a standard pressure between the jaws, but none suitable for measuring a small fragile object such as the skull of a shrew could be found. Mr. G. H. C. Jones, of the Science Museum, London, designed and made a measuring instrument specially for this purpose. This consisted of a lever pivoted near one end and counterpoised by means of a plunger within a solenoid. By operating a rheostat, a stylet attached to the short end could be brought to bear with constant pressure upon skulls resting on a metal plate. The measurement could then be read directly from a scale behind the other end of the lever. In order to measure depth of the brain-case, each skull was placed upside down upon the plate, the nasals resting on a wedge of 'Plasticine' to bring the floor of the brain-case to the horizontal. The stylet was then applied to the centre line of the basisphenoid. This gave the distance from the ventral surface of the basisphenoid to the highest point on the dorsal surface of the parietals. These measurements are smaller than those given by Dehnel[3] for brain-case depth in the same species, as his measurements were taken from the bullæ.

The depths of the brain-cases of 423 *Sorex araneus* from Wytham Estate, Berkshire, were measured in this way. The animals were taken in all seasons during October 1949–November 1951, and their reproductive condition and approximate ages were known. Thus it was possible to separate adults from young of the year, and to plot the changes in brain-case depth occurring within one generation of shrews. In Fig. 1 the means of depths of brain-cases in monthly samples of shrews born in 1949 are shown, together with the 95 per cent confidence limits of the means. It is clear that mean depth of brain-case decreases significantly between October and January, increasing thereafter until July, and then decreasing again as the end of the life-span approaches. The figures for the shrews born in 1950 show a similar trend although the samples are too small to be treated statistically.

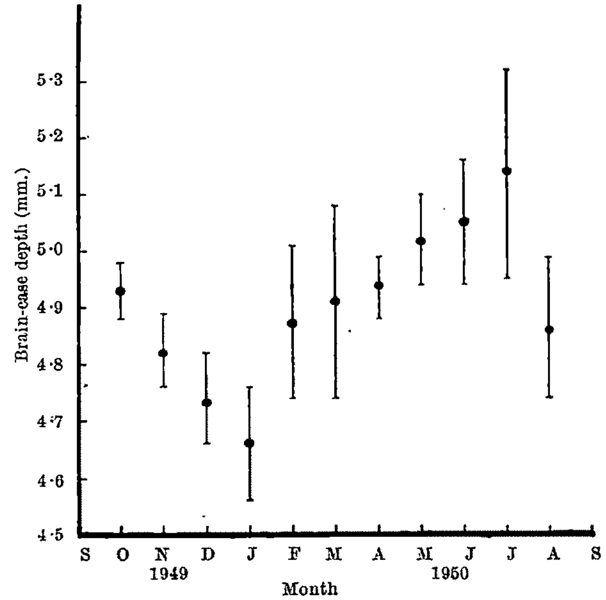

Fig. 1. Monthly means of depth of brain-case in *Sorex araneus*. Vertical lines show 95 per cent confidence limits

The hypothesis that the decrease in mean depth of brain-case is not due to shrinkage but to dilution of the population with small individuals from later litters cannot be supported, for the bulk of the annual 'crop' of common shrews is produced in June and July, very few females becoming pregnant as late as September. Furthermore, no breeding has ever been found to occur in *S. araneus* as late as December and January.

Thus Dehnel's "concertina" effect has been demonstrated in yet another population of common shrews and in a country with a much milder winter than that of eastern Europe. The more severe climatic changes suffered by the Continental shrews may account for their greater seasonal variation in brain-case depth. Similar studies of shrews from various regions of North America would be of great interest. Clothier[9] reported some variation in skull height in *Sorex vagrans* from Montana (U.S.A.), but it was not statistically significant. Similar studies of samples of this species from the extremes of its range may provide a means of assessing the effect of climate on seasonal skull variation.

In addition to recording our gratitude to the Director of the Science Museum, and to Mr. G. H. C. Jones, we wish to thank Mr. M. D. Mountford, of the Nature Conservancy, for carrying out the statistical analysis.

Peter Crowcroft
Jean M. Ingles

Zoology Department,
British Museum (Natural History),
London, S.W.7.
Jan. 13.

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Entry of Spermatozoa into the Fallopian-Tube Mucosa

It was reported recently that spermatozoon heads had been observed in the mucous membrane in histological sections of the Fallopian tube of two greater horseshoe bats (*Rhinolophus ferrum-equinum*) and four common pipistrelles (*Pipistrellus pipistrellus*)[1]; spermatozoa were not found in the uterine tissues. Similar observations have since been made in two rats, one rabbit, one hedgehog (*Erinaceus europaeus*), one mole (*Talpa europaea*) and two stoats (*Mustela erminea*). Spermatozoa considered to be in the mucosa were all in the thickness of the section and not on the surface. They were found even in individuals in which the lumina of tube and uterus contained few if any spermatozoa. When spermatozoon heads lay close to mucosal-cell nuclei, there was generally evidence of a local reaction, namely, a flattening or indentation of the opposed surface of the nucleus. Spermatozoa were not seen in sub-mucous tubal tissues. It is concluded, therefore, that the phenomenon is real, and not attributable to artefact, and that it is probably general.

In some respects, these observations resemble those of Kohlbrugge[2], who claimed to have identified spermatozoa within the uterine mucosa in elasmobranch fish (*Scyllium* and *Torpedo*), the domestic fowl, bats of two species (*Xentharpya amplexicaudata* and *Pterogistes stenopterus*) and the rabbit, and also within the Fallopian-tube mucosa in the mouse. Spermatozoa were said to pass into the sub-mucous connective tissue of the uterine wall in *Xentharpya*. Kohlbrugge maintained that the invading spermatozoa exerted upon the uterus a trophic influence that not only played a part in the ensuing pregnancy, but also persisted and constituted part of the mechanism of telegony. Kohlbrugge's work and ideas have received support especially from Russian investigators[3]. However, serious doubts concerning the validity of conclusions drawn from histological studies have been raised by Vojtiskova[4]. She considers that previous reports, including her own earlier paper, were misleading because what the authors had interpreted as spermatozoa which had penetrated uterine tissues *ante mortem* were in reality luminal spermatozoa displaced during the preparation and cutting of the tissue and transferred to other parts of the sections. Consistently with this view, Austin[5], Pósalaky and Törő[6], and Edwards and Sirlin[7] announced that they could find no evidence that spermatozoa entered uterine tissues in the rat and mouse.

There is little doubt that, in the past, workers may often have been misled by artefacts in their material; but the new findings here described show that it would be rash to discount all previous reports on these grounds. Since incorporation of spermatozoa into the female tissues could have far-reaching immunological and genetic consequences, a re-investigation of the claims of Kohlbrugge and others is well justified.

I am greatly indebted to Dr. Ruth Deanesly for the opportunity of examining her histological preparations of material from *Pipistrellus*, *Erinaceus*, *Talpa* and *Mustela*, and to Mr. Michael Blackmore for collecting the specimens of *Rhinolophus*.

C. R. Austin

National Institute for Medical Research,
Mill Hill, London, N.W.7.

Jan. 13.

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An Abnormality in the Skin of Sheep

THE normal procedure for fellmongering (removing the wool) English skeep skins is to paint the inner surface of the flayed skin with a paste of sodium sulphide solution thickened with lime. After allowing time for the chemicals to penetrate the dermis and dissolve the roots of the wool, the wool is pulled. The epidermis is also removed and the pelt is left in a semi-swollen condition. The pelt then goes forward to the subsequent processes of leather manufacture.

In the course of work on a new method of fellmongering involving treatment with proteolytic enzymes in place of sulphide and lime, the pelt, which is completely flaccid and unswollen when the wool is pulled, frequently showed a blistered effect on the grain (the epidermis – dermis junction forms the grain surface of the leather). The blisters appeared like small air bubbles up to about 3 mm. in diameter trapped under the grain, and they could be pushed around with the finger. They occurred only on fine-woolled skins and always in the areas around the hind shanks, occasionally extending a considerable distance towards the neck (Fig. 1). Lamb skins were affected more than sheep skins: in some packs of lamb skins as many as 40 per cent were affected. The phenomenon was independent of the temperature of treatment of the skins over the range 21–32° C.

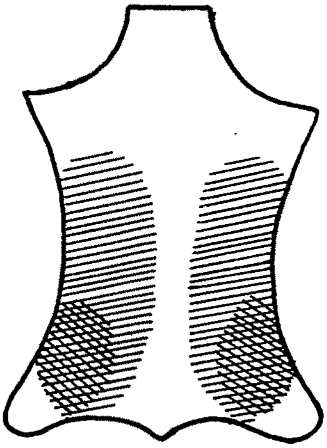

Fig. 1. Diagram of sheep skin showing areas susceptible to blistering. The cross-hatched areas are those which most frequently show the defect, but it occasionally extends over the line-shaded areas

The blisters were found microscopically (paraffin and frozen sections stained with azure *A*) to be associated with cavities occurring at all levels in the dermis. They were already present in the untreated skin and hence were not a condition induced by processing. Fig. 2 shows them in the papillary layer between the wool follicles of the untreated skin, and Fig. 3 in the dermis of the same section near the inner limiting layer. The wall of the cavity seems to be formed by the rearrangement, but not thickening, of ordinary fibres of the dermis. No contents such as fat, micro-organisms or infesting parasites have been observed within the cavities.

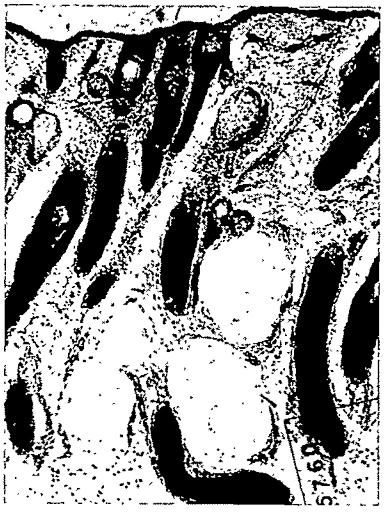

Fig. 2. Papillary layer of blistered sheep skin showing four cavities among the hair follicles (frozen section, azure *A*. × *c*. 57)

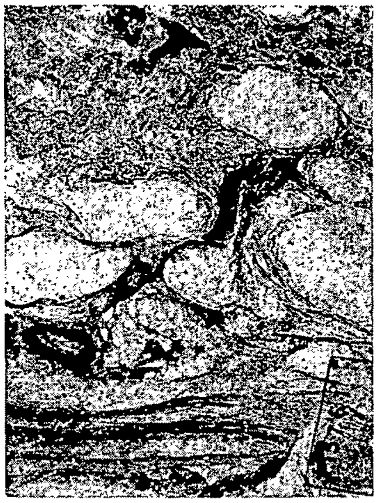

Fig. 3. Dermis of blistered sheep skin, near the inner limiting layer (frozen section, azure *A*. × *c*. 57)

No mention of this phenomenon is made by Seymour-Jones in his authoritative work on sheep skins[1]. Before sulphide and lime came into use, English skins were sweated, a bacterial process related to enzyme dewoolling but subject to much less control, which would leave the pelt in essentially the same flaccid condition as after enzyme treatment. It is possible that the condition was overlooked by Seymour-Jones, since the sweating process had long since been abandoned, or the breeds of sheep that were reared in the days of sweating were not subject to this phenomenon: there has been a progressive change in the types of sheep being bred over the past century. Apart from classifying the type of sheep subject to this blister as fine-woolled, no more exact designation can be given owing to the large amount of cross-breeding that is carried out resulting in the receipt by the fellmonger of miscellaneous types of cross-bred skins. The failure to observe the blisters in recent years is most likely due to the fact that the susceptible area is not often examined by leather microscopists, and to the probable collapse of the cavities during manufacture of the skin into leather.

Note added in proof. Since the above was written, Mr. J. Tate, who has been connected with the fellmongering industry for seventy years, has confirmed that sweated domestic sheep skins were subject to blistering, and the cause was unknown.

MARY DEMPSEY
G. H. GREEN

British Leather Manufacturers'
Research Association,
Milton Park,
Egham. Jan. 15.

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Abnormal Resistance of *Poria vaillantii* (D.C. ex Fr.) Cke. Strains to Copper–Chrome–Arsenate Wood Preservatives

CERTAIN species of *Poria* causing brown rot in wood, including *P. vaporaria* (Pers. ex Fr.) Cke., *P. vaillantii* (D.C. ex Fr.) Cke., *P. xantha* (Fr.) Cke., and *P. monticola* Murr., are much more resistant to the toxic effects of simple copper salts than are most wood-destroying fungi, but have been readily inhibited by the copper–chrome–arsenate preservatives which are now in common use[1]. During wood-block tests of wood preservatives in this laboratory, however, one strain of *P. vaillantii* was found to be unaffected by these preservatives at the usual concentrations, and the tolerance of various strains of the species was therefore investigated by testing their ability to decay sawdust treated with increasing concentrations of such preservatives, using a modification of the sawdust dish – soil jar decay resistance test of Da Costa and Rudman[2].

A 4-gm. sample of air-dry sawdust (23–72 mesh) of the sapwood of *Pinus radiata* D. Don was mixed thoroughly with 7·5 ml. of the appropriate preservative solution, packed down tightly, and left 1–3 days to allow the preservative to distribute itself uniformly through the sawdust particles and to react with the wood components. The treated sawdust was then vacuum dried at 40° C. with frequent stirring, and 0·4 gm. samples placed in aluminium foil dishes (1 in. diam.; $\frac{3}{4}$ in. high) with perforated bottoms. The dishes of sawdust were sterilized by fumigation with propylene oxide and placed on pure cultures of the test fungus on thick filter paper disks, soaked in a solution of 2 per cent dextrose, 0·4 per cent casein hydrolysate, 0·4 per cent peptone, 0·05 per cent crystalline magnesium sulphate, 0·15 per cent potassium dihydrogen phosphate, 0·001 per cent thiamine hydrochloride, and resting on moist soil in glass jars. After incubation at 25° C. and 99 per cent relative humidity for 5 weeks, the dishes were vacuum dried and re-weighed and the amount of decay expressed as the percentage loss in oven-dry weight.

Initial tests with a typical proprietary preservative of the copper–chrome–arsenate type (Table 1) showed that the high tolerance previously noted was not shared by species of *Poria* of similar habit, or indeed by all strains of *P. vaillantii*. There were, however, three tolerant strains of very diverse origin, the most tolerant being *DFP*4443, which had been isolated originally from *Pinus radiata* treated with a copper-chromate preservative. This strain was used for making further tests with individual compounds commonly used in highly fixed water-borne inorganic preservatives of the metal–chrome–arsenate type.

Each compound was tested in a wide range of concentrations (for example, crystalline copper sulphate, 0·01, 0·015, 0·02, 0·03, 0·04, 0·06, 0·08, 0·12, 0·16, 0·24, 0·48, 0·64 'molal', where 1 'molal' has 1 gm. molecular weight added to 1,000 gm. of sawdust), and certain commonly used combinations

Table 1. RESISTANCE OF *Poria* SPP. TO A COPPER–CHROME–ARSENATE PRESERVATIVE

Species	Isolate number *DFP*-	Origin	Amount of decay at preservative concentration*					
			0·0	0·1	0·4	1·6	3·2	6·4
Poria vaporaria (Pers. ex Fr.) Cke.	2392	England	57†	—	—	—	—	—
Poria xantha (Fr.) Cke.	3839	Australia	63	1	—	—	—	—
Poria sp.	6625	Australia	64	7	—	—	—	—
Poria sericeomollis (Rom.) Bax.	4911	Australia	67	17	1	—	—	—
Poria vaillantii (D.C. ex Fr.) Cke.	3112	Australia	35	—	—	—	—	—
	5227	Australia	62	41	—	—	—	—
	2375	England	51	56	52	51	13	—
	2446	Canada	62	53	55	36	25	2
	4443	New Zealand	58	61	64	39	38	20

* Gm. of dry salt added to 100 gm. oven-dry sawdust.
† Percentage loss in weight — mean of three replicates.

Table 2. TOXICITY OF COMPONENT SALTS OF PRESERVATIVES TO *P. vaillantii* STRAIN *DFP* 4443

Preservative	Total inhibition point		
	'Molal' concentration	95 per cent fiducial limits	Percentage of dry salt
$ZnSO_4.7H_2O$	0·59*	0·14–2·53*	17·0†
$CuSO_4.5H_2O$	0·66	0·46–0·92	16·5
$Na_2Cr_2O_7.2H_2O$	0·37	0·27–0·51	11·0
As_2O_5	0·15	0·04–0·48	3·4
$CuSO_4.5H_2O$ + $Na_2Cr_2O_7.2H_2O$	0·33‡	0·16–0·70‡	18·1§
$CuSO_4.5H_2O$ + $Na_2Cr_2O_7.2H_2O$ + As_2O_5	0·25‡	0·15–0·44‡	19·4§
Copper–chrome–arsenate preservative	—	(16·0–31·6)†	23·0§

* Gm. molecular weights added to 1,000 gm. of oven-dry sawdust.

† Gm. of dry (not anhydrous) salt added to 100 gm. oven-dry sawdust.

‡ Concentration of each component.

§ Total percentage of all components.

were tested as equimolecular mixtures. From the dosage-response relationships obtained, the total inhibition point (that is, the minimum concentration of preservative necessary to reduce the weight loss to zero) was computed for each preservative (Table 2). For any one preservative the amount of decay produced was approximately in inverse proportion to the logarithm of preservative concentration: some preservatives showed significant, though slight, deviations from this relationship, and these have been taken into account in calculating the fiducial limits given.

The resistance of strain *DFP*4443 to copper and zinc is even higher than would be expected from previous reports on the copper-tolerant species of *Poria*, and this strain is also highly tolerant of arsenic. Later tests, in fact, show it to be more tolerant than *Lenzites trabea* (Pers.) Fr., which is widely used as an arsenic-tolerant fungus in testing wood preservatives. It is presumably this high tolerance of arsenic which distinguishes the strains found here to be tolerant of copper–chrome–arsenates from the *Poria* strains used elsewhere in tests of these preservatives.

I wish to acknowledge the assistance of Messrs. L. Bartak and J. M. Stephenson in these investigations, which will be reported more completely at a later date.

E. W. B. DA COSTA

Division of Forest Products,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
Dec. 12.

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Density-Dependent Factors in Ecology

ANDREWARTHA's ideas on density-dependent factors[1] in ecology are very misleading, and have already been criticized by Huffaker[2]. I wish to refer to three points which he raises in his recent communication. First, he argues that since the population models of Lotka and Volterra are based on density-dependent relationships, and these have been "partly confirmed by laboratory experiments with such simple animals as *Paramecium*, but not with more complex ones such as *Calandra* and *Tribolium* and not with any sort of animal in Nature", this is evidence against the applicability of ideas of density dependency. Yet density-dependent relationships are known to operate in two ways in *Tribolium* cultures. Chapman[3] found the beetles ate their own eggs, and Boyce[4] showed female beetles laid fewer eggs when crowded. The Lotka–Volterra formulæ have seldom been applied to interpret these happenings because they are not properly applicable to animals with a long pre-reproductive period. However, Crombie[5] has used the formulæ with encouraging success to interpret the results of competition between the beetles *Oryzaephilus* and *Tribolium* and other grain insects.

Secondly, he quotes Nicholson's formula[6] relating the equilibrium population density N_E of an animal to its food supply g:

$$N_E = \frac{g - lg - wg}{q}$$

where l is the fraction of food lost to extraneous factors and w the fraction wasted by surplus individuals which fail to mature, and q the quantity of food required to complete development. By putting $w = 0$ or 1 Andrewartha claims to 'solve' the equation, whereas he is determining only the limits of possible solutions. Since w is itself a function of the population density N, a solution can be obtained only if the appropriate function of N is substituted for w. If, however, the competitive scramble for food wastes a negligible amount so that $w = 0$, then $N_E = \frac{(g - lg)}{q}$, which has a simple biological meaning. Andrewartha's categorical assertion that "This does not satisfy the concept of an equilibrium density" seems to be a *non sequitur*.

I agree with Andrewartha that the experiment he outlines to test the action of density-dependent factors is unable to prove anything; but far better methods are available. Density-dependent factors can be identified by their observed effects at a variety of population densities, and their ability to reduce high populations either asymptotically or with damped oscillations to the equilibrium density can be checked.

For the idea of density-dependency to be useful, the idea must be properly understood. If factors are to be invoked to explain population stability, they must have certain well-defined properties[7]. To use the term inappropriately and in senses entirely different from the original definition causes nothing but confusion.

G. C. VARLEY

Department of Entomology,
University Museum,
Oxford.
Jan. 27.

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ANDREWARTHA[1] has criticized an equation which he wrongly designates my "equation for intraspecific competition". Actually, it simply represents symbolically the necessary conditions for equilibrium in a postulated simple situation, other equations being given for other simple situations. His conclusion that "the equation is a tautology" is wholly due to his unjustifiable assumption that this equation is intended to represent the operation of competition.

The same assumption underlies his conclusion that the equation "does not satisfy the concept of an equilibrium density", arguing that "solving the equation for values of w between 1 and 0 gives values of N_E between 0 and $\frac{g - lg}{q}$". (w is the fraction of the governing requisite wasted by the animals which scramble for it, N_E the equilibrium density of the population, g the rate of generation of the governing requisite, l the fraction of this lost to the animals due to other agencies, and q the amount of the requisite required by an animal for development to maturity). The implication is that w, and therefore N_E, are indeterminate. However, as with the other parameters in the equation, the equilibrium value of w is determined by properties of the animals and those of the environment, and not by the equation. Andrewartha appears to have overlooked the statement[2], which immediately precedes the equation, that the "surplus individuals waste a fraction (w) of the governing requisite, in the sense that this fraction is rendered unavailable to those individuals which maintain the population by maturing and reproducing". Thus at equilibrium the value of w is positively related to the fraction of offspring which is surplus, and is influenced by the relation existing between crowding and the wastage (wg) of the governing requisite.

The equation under discussion is $N_E = \frac{g - lg - wg}{q}$, which does not purport to indicate how competition can bring about equilibrium. This question is discussed verbally and mathematically in neighbouring parts of the same article[2], but Andrewartha makes no reference to this discussion. It can readily be outlined by reference to the equation. Keeping in mind the fact that the fraction (w') of the governing requisite, say, food, which is wasted by the scrambling animals is positively related to the population density (N) at any given time, it is easy to see that when $N < N_E$ the wastage of food at that time is relatively low, that is, $w' < w$. More of the food is therefore available for the development of mature animals, and so $N \rightarrow N_E$, as similar arguments show it does when $N > N_E$. Thus competition among the animals sets up reactions which always tend to cause an approach to the equilibrium density. However, as the development of animals takes time, there tends to be an alternate over-shooting and under-shooting of the equilibrium density, for there is a delay in the operation of the corrective reaction induced at any given density.

Having determined the diminution of egg production by adults, and the increase of larval mortality, due to the wastage of food caused by different degrees of crowding in cultures of *Lucilia cuprina*, I was able to deduce the very varied patterns of population-growth and maintenance and the greatly differing levels populations would maintain, or oscillate about, under different specified conditions. These deductions were tested experimentally by subjecting populations of this blowfly to the postulated conditions, and the results obtained always agreed closely with expectation. Some of these experiments have already been described[2,3]. They all clearly demonstrated the governing function of density-induced reaction, which was the primary hypothesis underlying my predictions. Many other investigators have also successfully used the underlying idea of 'density-dependent factors' to assist them in their experiments and observations. Andrewartha's claim that this idea has been unfruitful is untenable.

At no time have I argued, as Andrewartha claims, "that only density-dependent factors can keep a population from becoming extinct", except in the special sense that such factors alone can prevent populations in favourable situations from becoming so large that they endanger their own existence. The views I have expressed[4] are that animals are necessarily excluded from all inherently unfavourable regions; that within favourable regions they characteristically multiply when unchecked; and that growth to indefinitely large numbers is prevented by density-induced opposition, such as the depletion of requisites, which automatically adjusts populations at, or fluctuating about, levels related to the properties of the animals and those of their environments. There is no need to attempt the impossible task of proving a null hypothesis by an experiment of the kind Andrewartha mentions. The views I have just expressed form a positive hypothesis which not only can be, but already has been, tested and confirmed by many experiments, as I have just indicated.

A. J. NICHOLSON

Division of Entomology,
Commonwealth Scientific and
Industrial Research Organization,
Canberra.

Feb. 6.

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Fossil Reptiles from the Panchet Beds of India

WHILE preparing an exhibition of nothosaurs and other reptiles of Triassic age from Poland (held at the Geological Society of London on January 28), I realized from Dr. W. E. Swinton's paper[1] that nothosaurs are found at widely separated localities along the shores of the ancient sea of Tethys, from Europe eastwards to Japan. It would thus be reasonable to expect further nothosaur remains anywhere in this belt.

Another band of deposits containing Triassic reptiles is known—part of the Gondwana System—this time stretching from South Africa to Central Asia. This meets Tethys in northern India. Here one should find a mixture of the two faunas and would look for nothosaurs together with a Gondwanaland reptile, which, like them, had a wide distribution and was aquatic. From the literature[2] I found that such an animal was already known from India, namely, the dicynodont *Lystrosaurus*.

Dr. G. de P. Cotter in 1917[3] in his "Revised Classification of the Gondwana System" suggested that the dicynodont material described by Huxley[4] and Lydekker[5] from the Panchet Beds of Bengal belonged to the genus *Lystrosaurus*, and used its presence to correlate these beds with the basal Trias of South Africa. He did not, however, discuss the material as he was concerned solely with stratigraphy. In 1922[6], the late H. C. Das Gupta, professor of geology in Calcutta, in his "Notes on the Panchet Reptile", gave the history of the genus in India and, by means of a detailed discussion of the known skeletal elements, confirmed that Huxley's and Lydekker's material should be placed in *Lystrosaurus*. In addition, he described further *Lystrosaurus* remains that he himself had collected from the Panchet Beds.

Later, Das Gupta[7] described and figured from the same beds a small reptilian vertebra which he considered to be rhynchocephalian, but which is very similar to some of the nothosaur vertebræ from Poland, and is amphiplatyan not amphicœlous as in the Rhynchocephalia. I consider, therefore, that it belongs to a nothosaur.

Thus it would seem that Prof. Das Gupta, even though not aware of it, by finding both nothosaur and *Lystrosaurus* remains in the Panchet Beds, made an important contribution which may well help to effect a closer correlation of the Gondwana System with the Tethyan deposits than has hitherto been possible.

It is good to see that the work of these earlier writers, who had only fragmentary remains for study, should now be so fully confirmed by Dr. P. L. Robinson's account of the recent discovery of more complete remains of *Lystrosaurus* in India[8].

L. B. Tarlo

Department of Palæontology,
British Museum (Natural History),
London, S.W.7. Jan. 22.

[1] Swinton, W. E., *Ann. Mag. Nat. Hist.*, (Ser. 12), **5**, 875 (1952).

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Many previous writers have suggested that the dicynodont present in the Panchet sandstones might be *Lystrosaurus*. Some, such as de P. Cotter, were not concerned with a review of the dicynodont material available but had some particular stratigraphic axe to grind. Others (Lydekker, Das Gupta, von Huene) have directed attention to certain features of the few fragments available. It is probably not possible to identify *Lystrosaurus* on such fragments. Many characters can be matched individually with those seen in some other dicynodont. A complex of characters, and in particular the key characters of *Lystrosaurus* which are dependent on the relative shortness of the temporal region as compared with length and depth of snout region, can obviously only be assessed on a reasonably complete skull. The matter has been well expressed by Das Gupta[1], " . . . without the discovery of an entire skull, the zoological position of the Panchet reptile cannot be definitely settled. . . ".

I take it that the vertebra diagnosed as nothosaurian by Tarlo is the worn centrum figured by Das Gupta in 1928[1] (Plate II, Fig. 4). The edges of the centrum are so abraded that I feel that a diagnosis of it as originally amphiplatyan is uncertain.

I believe that the description, by Tripathi and Satsangi of the Geological Survey of India, of the new *Lystrosaurus* remains from the lower Panchets, and a careful comparison with the South African and Chinese forms, will be a major contribution to our understanding of the stratigraphy of the Gondwana Group of India. I was delighted to hear from the director of the Geological Survey of India, Dr. B. C. Roy, that he had decided that field work on the Panchets should be continued, and that Tripathi and Satsangi are again making a collection from these rocks. We must wish them success and hope that further discoveries of good specimens of the Panchet fauna will relieve us of the need to burden the literature with identifications made on fragmentary bones.

Pamela Lamplugh Robinson

Department of Zoology,
University College, London.
March 5.

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ENTOMOLOGY

Proepithelial Regeneration in the Midgut of Beetles

The columnar cells of the midgut epithelium in most insects are continually replaced by new cells produced by the division of special regenerative cells. The latter are usually scattered singly or grouped into nidi or else form deep crypts. Pradhan[1], however, described a new process in *Coccinella septempunctata* (Coleoptera, Coccinellidae) and other carnivorous coccinellids where the new cells (pro-epithelial cells) are grouped around large cavities or vacuoles. When the old epithelium is shed, the pro-epithelial cells move into their place. He states that "the presence of this peculiar process of regeneration (pro-epithelial regeneration) in the carnivorous coccinellids and its absence in the herbivorous species forms the most striking difference between the carnivorous and herbivorous midguts". However, in the case of *Epilachna vigintioctopunctata* Fabr., a common herbivorous coccinellid studied by us, pro-epithelial cells grouped around large vacuoles (about 20μ in diameter) could easily be seen (Fig. 1). The vacuoles are present throughout the midgut but are most clearly seen in the middle portion of it.

The function of the vacuoles is obscure. Pradhan[1] speculated that they have a macerative action and are responsible for shedding the old epithelium. In the present material it was noticed that the contents of the vacuoles are not purely watery but give a

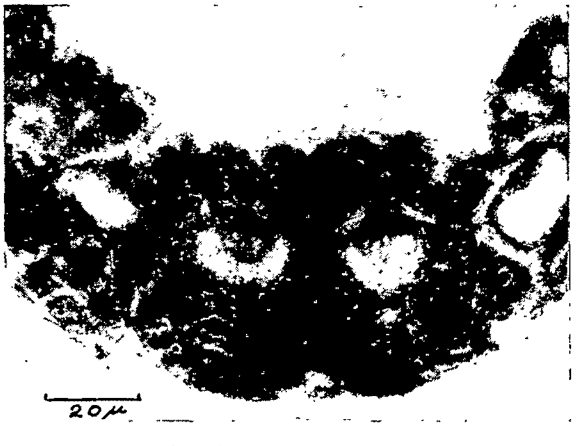

Fig. 1. Section through the middle portion of the midgut of *Epilachna vigintioctopunctata* showing the large vacuoles and the pro-epithelial cells around them

positive periodic acid Schiff reaction of MacManus[2]. Further studies on the vacuoles are in progress.

M. Ameen
S. A. Shafiq

Department of Zoology,
University of Dacca,
Pakistan. Jan. 12.

[1] Pradhan, S., *Quart. J. Micro. Sci.*, **81**, 451 (1939).

[2] MacManus, J. F. A., *Nature*, **158**, 202 (1946).

Respiration of Corixidae (Hemiptera-Heteroptera)

Pterygote insects originally evolved as terrestrial animals, but various families of Hemiptera have since colonized aquatic habitats. Corixids live on the bottom, feeding mainly on algae and detritus. Air carried on the hydrophobe body surface functions as a 'physical gill'[1-4]. The thoracic tracheal system is well developed. The ventrally situated anterior thoracic spiracles occur between the pro- and ptero-thorax. The dorsally placed posterior thoracic spiracles occur laterally to the wing bases. The anterior abdominal spiracles occur dorsally, just posterior to the thorax. On each side these spiracles are joined by a wide, lateral, longitudinal tracheal trunk, which supplies tracheæ to the flight and leg muscles. The tracheæ from each of the ventrally placed abdominal spiracles supply gonads and gut, but, except for the dorsally placed vestigial longitudinal tracheal trunks, are unconnected with other tracheæ of the same or adjacent segments. The passage of gas anteriorly through the thorax (a centre of high oxygen consumption) is largely independent of that through the abdomen where the consumption of oxygen is relatively low.

During submergence, gas is expired from the anterior thoracic spiracles into the space between the pro- and ptero-thorax, to be moved backwards over the surface of the body by the hind legs, which bear special hydrophobe setæ for this purpose. The abdomen is dorso-ventrally flattened to facilitate gaseous exchange between the gas stores and water. Oxygenated gas is inspired through the first pair of abdominal spiracles to pass forwards through the thorax. Considerations of the arrangement of the thoracic sclerites and metathoracic leg muscles show thoracic ventilation is probably automatic during swimming.

Corixids normally come to the surface when deficient in oxygen. By illuminating experimental tanks obliquely from one side it was possible to show corixids are positively phototactic while surfacing, and negatively phototactic when returning to the bottom. This implies that corixids are positively phototactic when deficient in oxygen and negatively phototactic when sufficient oxygen has been obtained. These conclusions are supported by independent evidence of the reactions of corixids to light before and during flight.

Corixids usually occur in shallow water. Hagemann's organs occur immediately in front of the posterior thoracic spiracles. Stimulation of these organs causes surfacing. Under natural conditions this occurs when corixids wander to a depth where there is a danger of water entering the spiracles and flooding the tracheal system. So far no evidence is forthcoming to confirm Hagemann's suggestion that this organ has an auditory function[5].

Corixids renew their superficial gas stores by momentary contact with the atmosphere. At the water surface the pronotum is raised from the front of the hemi-elytra and air rushes over the hydrophobe body surface to dilate the gas stores. Holdgate[6] has shown that aquatic insects with a roughened surface have a high advancing and retreating angle when wetted. During surfacing the rastration of the pronotal and corial surfaces of some species accelerates exposure of the pronotal-hemi-elytral junction and retards the return of water when gas store replenishment is completed.

Cutaneous respiration occurs in the early nymphal instars, but is gradually replaced in later instars and adults by the superficial gas stores acting as a physical gill. As nymphs grow, the increase of cuticular thickness and the reduction in the relative size of the body surface decrease the efficiency of the skin as a respiratory organ. This is compensated by a corresponding increase of relative gas store size: gaseous exchange occurring more rapidly through the air-water interface of the gas stores than through the cuticular body surface.

The physical gill is associated with secondary modifications of body form. The surface gas bubbles make the insect less dense than water. To progress along a horizontal path the hind legs are kicked backwards and upwards. This drives the corixid not only forwards but also slightly downwards to compensate for the tendency to float towards the surface between each leg kick[3]. This mode of locomotion is associated with a forward slant of the thoracic segments and an inward rotation of the hind coxæ: changes which are well illustrated by comparison of the thoracic segments of *Micronecta* and *Corixa*.

While copulating, corixids come to the surface several times. The sexes when joined cannot surface normally because the male is relatively immobile and the female, being ventral to the male, cannot make contact with the surface in the usual way. The male abdomen is asymmetrical and the ædeagus is extruded to the left in *Corixa punctata* and to the right in most British species. Surfacing is accomplished by the pair rolling over on the side of the male asymmetry, thereby allowing the other side of the abdomen ample freedom of movement for gas store replenishment.

In the Corixidae, the reduction of the longitudinal abdominal tracheæ has made it possible for gas to be passed anteriorly through the thorax and for the efficiency of the physical gill to be increased. Compared with other aquatic Hemiptera (for example, Nepidae, Naucoridae and Notonectidae) corixids are less directly dependent upon atmospheric oxygen. Their emancipation from the surface (though not so complete as in *Aphelocheirus aestivalis*[4]) has enabled the family to undergo adaptive radiation to a wide range of aquatic microhabitats and to evolve into more Palæarctic species than occur in the remainder of the Cryptocerata.

Edward J. Popham

Department of Zoology,
University,
Manchester.
Jan. 12.

[1] De Ruiter, L., *et al.*, *Acta Physiol. Pharmacol. Neer.*, **2**, 180 (1952).

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[4] Thorpe, W. H., and Crisp, D. J., *J. Exp. Biol.*, **24**, 227, 270, 310; **26**, 219 (1947-49).

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FORTHCOMING EVENTS

Wednesday, April 1

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. J. S. Elliott, Mr. N. E. F. Hitchcock and Mr. E. D. Edwards: "Hypoid Gear Lubricants and Additives".

Society of Chemical Industry, Food Group—Nutrition Panel (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Annual General Meeting, followed by Prof. Hugh Nicol: "Facts About Food Supplies".

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. S. J. Read: "Discriminators (F.M. Detectors) with particular reference to the Bond Disc".

Society for Analytical Chemistry (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

Thursday, April 2

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. R. E. Holttum: "Growth-habits in Monocotyledons"; Mr. E. M. Marsden-Jones: "Genetics and Pollination of *Anagallis arvensis* subsp. *arvensis* and *A. arvensis* subsp. *Foemina*".

Institute of Refrigeration (at the Institute of Marine Engineers, The Memorial Building, 76 Mark Lane, London, E.C.3), at 5.30 p.m.—Mr. W. R. Hall: "The Measurement and Determination of Noise in Small Refrigerating Machines".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Women in Engineering" opened by Sir Willis Jackson, F.R.S.

Society of Chemical Industry, Microbiology Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by Dr. P. W. Brian, F.R.S.: "Some Ecological Consequences of Production of Extracellular Metabolites by Micro-organisms".

Polarographic Society (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Polarographic Problems Encountered in Industrial Medicine" introduced by Mr. K. Baker and Mr. L. King.

Friday, April 3

Biochemical Society (in the Department of Biochemistry, University College, Gower Street, London, W.C.1), at 10.30 a.m.—Annual General Meeting.

Manchester Statistical Society, Industrial Group (in the Portico Library, 57 Mosley Street, Manchester), at 6 p.m.—Mr. L. H. C. Tippett: "Recent Developments in the Measurements of Productivity in the Textile Industry".

Society of Dyers and Colourists, London Section (at the George Hotel, Luton), at 7 p.m.—Dr. T. Vickerstaff: "Recent Developments in Dyeing".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Chair of Philosophy tenable in the Durham Division of the University—The Registrar, University Office, 46 North Bailey, Durham (April 9).

Lecturers (with a good honours degree and relevant teaching experience) in Geography, Chemistry, Physics and Mathematics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (April 10).

Research Fellow (with an interest in physical-organic chemistry and some postgraduate experience in preparative chemistry) in the Department of Chemistry—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 10).

Senior Lecturer (with a good honours degree and some previous teaching experience) in Mathematics—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1 (April 10).

Lecturer in Organic Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 13).

Assistant Experimental Officer or Experimental Officer (zoologist, preferably with an interest in entomology) at the Freshwater Fisheries Laboratory, Pitlochry, to be a member of a small team working on the bottom fauna of freshwaters—The Establishment Officer, Scottish Home Department, Room 364, St. Andrew's House, Edinburgh 1 (April 15).

Professor of Applied Physics in the Durham Division for a new Department of Applied Physics due to open in October 1960—The Registrar, University Office, 46 North Bailey, Durham (April 16).

Lecturer (graduate with qualifications, training and teaching experience in mathematics) in the Department of Education—The Registrar, The University, Leicester (April 18).

Research Assistant (with an honours degree in statistics or an honours degree in mathematics, together with some knowledge of statistical methods) in Statistics, for duties which include computation, programming for a computer, demonstration and a small amount of teaching—The Registrar, The University, Sheffield (April 18).

Research Fellow (with Ph.D. or equivalent experience in an appropriate subject, such as biochemistry, animal or plant physiology) at the Marine Biology Station, for research into mechanisms of toxicity—The Registrar, University College of North Wales, Bangor (April 18).

Assistant Lecturer in Physics—The Registrar, University College of North Staffordshire, Keele, Staffs (April 20).

Lecturer (preferably medically qualified) in Physiology—The Secretary, The University, Aberdeen (April 20).

Technician (preferably with experience in workshop practice or in histological techniques) at the Marine Biology Station—The Registrar, University College of North Wales, Bangor (April 20).

University Demonstrators and Departmental Demonstrators in Biochemistry, Ecology, Physiology and Virology—The Sherardian Professor of Botany, Botany School, The University, Oxford (April 20).

Tutor or Lecturer (woman, with special qualifications in either experimental or theoretical physics) in Physics—The Treasurer, Somerville College, Oxford (April 21).

Senior Lecturer or Lecturer in Philosophy at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 23).

Chair of Physiology at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 24).

Research Assistant (with a first- or second-class honours degree in chemistry) in the Chemistry and Metallurgy Department—The Principal, Coventry Technical College, Butts, Coventry (April 24).

Lecturer or Assistant Lecturer in the Department of Zoology and Comparative Physiology—The Registrar, The University, Birmingham 15 (April 25).

Assistant Lecturer in Inorganic Chemistry—The Registrar, The University, Hull (April 27).

Reader in Geography at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 27).

Clinical Lecturer (medical graduate with experience in bacteriology, immunology or virology, and in research methods) in Microbiology—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Otago, Dunedin, New Zealand (New Zealand, April 30).

Research Assistant (with an honours or good pass degree in agriculture or equivalent) in the Department of Agriculture, for grazing studies in connexion with grassland irrigation—The Registrar (Room 22, O.R.B.), The University, Reading (April 30).

University Lecturer in History of Science—Mr. R. F. Holmes, The Old Schools, The University, Cambridge (April 30).

Senior Lecturer in Physics—The Registrar, The University, Hull (May 1).

Assistant Lecturer or Lecturer (preferably with a special interest in mineralogy and petrology or in economic geology) in Geology at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 10).

Assistant (Grade B) to teach Physics, Mathematics and Chemistry to Advanced Level G.C.E.—The Principal, North-West Kent College of Technology, Miskin Road, Dartford.

Clinical Biochemist, to assist in research into metabolic changes accompanying burns—The Group Secretary, Booth Hall Children's Hospital, Blackley, Manchester 9.

Demonstrator in the Plant Physiology Department, for teaching and to carry out research—The Professor of Plant Physiology, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

Lecturer in Botany—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

Lecturer in Chemistry; a Lecturer in Physics; and Grade B Assistants in Chemistry, Physics and Mathematics—The Principal, Reading Technical College, King's Road, Reading.

Lecturer (with proved research ability in physical metallurgy or in metal physics) in Physical Metallurgy—Prof. J. G. Ball, Metallurgy Department, Imperial College of Science and Technology, London, S.W.7.

Master to teach Mathematics up to Scholarship Level—The Headmaster, Cheltenham College.

Mathematics Master, principally to share Sixth Form teaching up to Scholarship Standard with some work in the Middle School—The Head Master, University College School, Frognal, Hampstead, London, N.W.3.

Research Assistant (science graduate, preferably with previous experience in serology and blood-group studies), to carry out experimental work in animal blood-groups—The Administrative Secretary, School of Veterinary Medicine, The University, Madingley Road, Cambridge.

Scientific Assistant (Abstractor) (with a degree in agriculture or natural science and a knowledge of languages)—The Director, Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire.

Scientific Officer (Petrologist) (with a first- or good second-class honours degree in geology and at least five years postgraduate experience in petrology) in the Geological Survey Department, Federation of Nigeria, for duties which will include petrological and mineralogical work in the Geological Survey Laboratories, with good opportunities for research—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/06.

Senior Assistant in Agricultural Chemistry or Lecturer (Assistant, Grade II) in Agricultural Chemistry—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford, Essex.

Senior Lecturer in Electrical Power (Electricity Supply); a Senior Lecturer in Electrical Machines; a Lecturer in Electronics (Electrical Computing); a Lecturer in Electrical Engineering (Utilization); and an Assistant Lecturer in Electronics—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Senior Lecturer (well qualified physicist and preferably with some experience of the application of physics in industry) in Physics—The Registrar, Bradford Institute of Technology, Bradford 7.

Vice-Principal (with high academic qualifications, responsible experience in administration and teaching, and preferably some industrial experience), to assist in the general administration of the College—The Principal, Cambridgeshire Technical College and School of Art, Collier Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Electrified Production, No. 1 (November, 1958). A quarterly illustrated newsletter. Pp. 4. (London: Electrical Development Association, 1958.) [191

British Council. 1959–60 Scholarships Abroad: Scholarships offered to British Students by Foreign Governments and Universities. Pp. iii+37. (London: British Council, 1959.) [191

Department of Scientific and Industrial Research: Lending Library Unit. L. L. U. Translations Bulletin, January 1959. Pp. iii+70. Published monthly. Annual subscription: 53*s.* including postage. Single issues 4*s.* (London: H.M. Stationery Office, 1959.) [191

Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series 2, Vol. 21, No. 8: An Account of the Fishing Gear of England and Wales. By F. M. David. Pp. v+165. (London: H.M. Stationery Office, 1958.) 35*s.* net. [191

Building Research Station Digest No. 117: Condensation and the Design of Factory Roofs. Pp. 4. (London: H.M. Stationery Office, 1959.) 3*d.* [261

Imperial College of Science and Technology. Code of Practice Against Radiation Hazards. Revised edition. Pp. iii+27. (London: Imperial College of Science and Technology, University of London, 1958.) [261

Ministry of Supply. Reports on Plastics in the Tropics. No. 10: Synthetic Resin Bonded Laminated Sheet. Pp. 49. (London: H.M. Stationery Office, 1958.) 6*s.* net. [261

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 689, Vol. 242 (22 January 1959): Studies of the Post-Glacial History of British Vegetation. By H. Godwin. 14: Late-Glacial Deposits at Moss Lake, Liverpool. Pp. 127–149+plates 3 and 4. 10*s.* No. 690, Vol. 242 (22 January 1959): A Study of the Development of the Head and Pharynx of the Larval Urodele *Hynobius* and Its Bearing on the Evolution of the Vertebrate Head. By H. Fox. Pp. 151–205+plates 5–7. 27*s.* 6*d.* (London: Royal Society, 1959.) [261

Forestry Commission. Forest Record No. 38: Design of Poplar Experiments. By J. N. R. Jeffers. Pp. 19. (London: H.M. Stationery Office, 1958.) 1*s.* 9*d.* [261

Ministry of Education Pamphlet No. 36: Teaching Mathematics in Secondary Schools. Pp. viii+154. (London: H.M. Stationery Office, 1958.) 6*s.* net. [261

Glasshouse Crops Research Institute. Annual Report 1957. Pp. 161. (Littlehampton: Glasshouse Crops Research Institute, 1958.) 10*s.* [261

Department of Scientific and Industrial Research: Hydraulics Research Station. Hydraulics Research Paper No. 1: Resistance of Fluids Flowing in Channels and Pipes. By Peter Ackers. Pp. iv+39. 8*s.* 6*d.* net. Hydraulics Research Paper No. 2: Charts for the Hydraulic Design of Channels and Pipes. By Peter Ackers. Pp. iv+46. 12*s.* net. (London: H.M. Stationery Office, 1958.) [261

Mathematics Before Newton. By Prof. A. R. Manwell. (Inaugural Lecture given in the University College of Rhodesia and Nyasaland.) Pp. 57. (London: Oxford University Press, 1959.) 4*s.* net. [281

Department of Scientific and Industrial Research: Building Research Station. National Building Studies—Research Paper No. 27: Noise in Three Groups of Flats with Different Floor Insulations. By P. G. Gray, Ann Cartwright and P. H. Parkin. Pp. iv+61. (London: H.M. Stationery Office, 1958.) 4*s.* net. [281

Bulletin of the British Museum (Natural History). Entomology. Vol. 7, No. 8: New or Little Known Butterflies from Malaya. By Lt.-Col. J. N. Eliot. Pp. 369–391+plate 10. 8*s.* Zoology. Vol. 5, No. 6: Ear Plug Laminations in Relation to the Age Composition of a Population of Fin Whales (*Balaenoptera physalus*). By P. E. Purves and M. D. Mountford. Pp. 123–161+plates 5 and 6. 20*s.* (London: British Museum (Natural History), 1959.) [291

The Engineer Buyers Guide 1959. Pp. 960. (London: *The Engineer*, 1959.) 7*s.* 6*d.* [301

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British Hat and Allied Feltmakers Research Association. Eleventh Annual Report of the Director of Research for the year ended August, 1958. Pp. 20. (Manchester: British Hat and Allied Feltmakers Research Association, 1959.) [301

University of Birmingham. Report of the Vice-Chancellor and Principal for the calendar year 1958. Pp. 26. Accounts for the year ended 31st July, 1958. Pp. 36. Report of the Proceedings of the Council of the University for the year ended 31st December 1958. Pp. 18. (Birmingham: The University, 1958 and 1959.) [301

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 961, Vol. 242 (29 January 1959): A New Armoured Amphibian from the Upper Permian of East Africa. By A. L. Panchen. Pp. 207–281. (London: Royal Society, 1959.) 25*s.* [301

Other Countries

Museum of Comparative Zoology at Harvard College. Breviora. No. 97 (October 27, 1958): Fusion of Cervical Vertebrate in the *Erethizontidae* and *Dinomyidae*. By Clayton E. Ray. Pp. 11. No. 98 (December 12, 1958): Two New Species of *Bathylagis* from the Western North Atlantic with Notes on other species. By Daniel M. Cohen. Pp. 9. No. 99 (December 19, 1958): A New Subspecies of *Chamaeleo jacksoni* Boulenger and a Key to the Species of Three-Horned Chamaeleons. By A. Stanley Rand. Pp. 8. No. 100 (December 23, 1958): On the Pineal Organ of the Tuna, *Thynnus thynnus* L. By Uno Holmgren. Pp. 5. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1958.) [261

United States Department of Agriculture. Agriculture Information Bulletin No. 194: Salt Tolerance of Grasses and Forage Legumes. By Leon Bernstein. Pp. 7. (Washington, D.C.: Government Printing Office, 1958.) 5 cents. [261

Rensselaer Polytechnic Institute, Troy, New York. Annual Report, 1957–1958. Pp. 68. (Troy, New York: Rensselaer Polytechnic Institute, 1958.) [261

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Printed in Great Britain by FISHER, KNIGHT & CO., LTD., The Gainsborough Press, St. Albans,
and published by MACMILLAN & CO., LIMITED, at St. Martin's Street, London, W.C.2,
and ST. MARTIN'S PRESS, INC., 175 Fifth Avenue, New York 10, N.Y., U.S.A.
Saturday, November 21, 1959.